THE AMERICAN JOURNAL OF SCIENCE AND ARTS.

CONDUCTED BY

PROFESSORS B. SILLIMAN, B. SILLIMAN, JR.,

AND

JAMES D. DANA,

IN CONNECTION WITH

PROF. ASA GRAY, OF CAMBRIDGE,
PROF. LOUIS AGASSIZ, OF CAMBRIDGE,
DR. WOLCOTT GIBBS, OF NEW YORK.

SECOND SERIES.

VOL. XVIII.—NOVEMBER, 1854.

WITH SEVEN PLATES.

NEW HAVEN: EDITORS.
NEW YORK: G. P. PUTNAM & CO.

Printed by B. L. HAMLEN—Printer to Yale College.

CONTENTS OF VOLUME XVIII.

NUMBER LII.

SCIENTIFIC INTELLIGENCE.

NUMBER LIII.

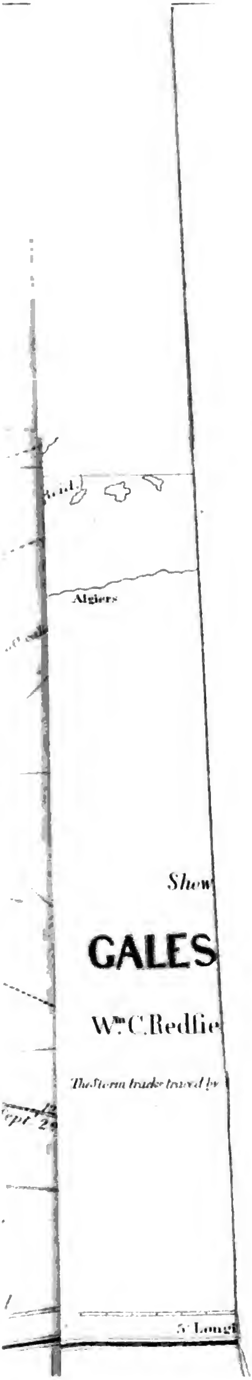
SCIENTIFIC INTELLIGENCE.

NUMBER LIV.

SCIENTIFIC INTELLIGENCE.

ERRATA.

P. 19, transfer last line to bottom of p. 18.
An error on p. 65 is corrected on p. 300.
P. 415, line 23 from top, dele "all but two of."
Vol. XVII, p. 287, line 10 from top, for "6 P. M.," *read* "10 P. M.:" same page, line 21 from bottom, for "59° 27," *read* "127° 9."


Algiers
Shew
GALES
Wm. C. Redfie
The Storm tracks traced by

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. I.—*On the first Hurricane of September* 1853, *in the Atlantic; with a Chart; and Notices of other Storms:* by W. C. Redfield.

Since I first ascertained the rotary and progressive movement of storms, in the year 1821, I have on various occasions endeavored to show some of the results which then became obvious or have been established in the progress of more extended investigations.* Of the results thus noticed, the systematic rotation of storms and gales in different regions, their opposite rotation and polar progression on opposite sides of the equator, and the mechanical influence of their rotary action on the movements of the barometer, when viewed in their practical relations, are the most important.

On the present occasion, I propose to give some account of the progression and extent of the earliest autumnal hurricane of 1853 in the north Atlantic. This case is not selected as differing in its essential features from other gales in the same region, but chiefly on account of the unusual extent of route that can be traced by direct observations. For it seems to have been inferred by some, that those gales which have previously been traced and

* See this Journal, vols. xx, xxv, xxxi, xxxv, and xlii, First Series; and vols. i and ii, New Series: with other communications. For further elucidations in this department of meteorology, since the year 1837, see the valuable publications of Col. Reid, Mr. Piddington, Surgeon Thom, and other writers.

their routes shown on our storm-charts, must have originated at or near the places where our first observations were obtained. It is obvious, however, that such inferences are quite erroneous.

It is not deemed necessary in this stage of the inquiry, to give such extensive elucidations of the rotation and geographical relations of the storm-wind as I have shown in the case of the Cuba hurricane of Oct. 1844.* I shall therefore only adduce in concise form such marine reports and observed phenomena as will serve to show the continued cyclonic violence, progress, and extension of the gale.

In submitting the reports by which its general route is established we shall follow the path of the gale westwardly, from off the Cape Verde Islands, crossing the Atlantic to the vicinity of Cape Hatteras, on the American coast, and from thence, on its recurvated course through the higher latitudes of the Atlantic, in the direction of the Spitzbergen sea, and touching, in its vast extension, the western shores of the British Islands.

1. The barque *William Money*, from Bombay, experienced heavy weather, with shifting winds, Aug. 30th and 31st, in lat. 13° N., lon. 29° W., with apparently worse weather in the vicinity.

2. *Independence*, from Talcahuano, Sept. 1st, in lat. 15° 40′, lon. 48° 20′, a violent hurricane, beginning at N. E. and ending at E. S. E.; lost all three topmasts.

3. *Sea*, dismasted in the gale, Sept. 2d, lat. 16° N., lon. 50° 30′ W.

4. *Warwick*, Sept. 3d, severe hurricane, lat. 16°, lon. 51° W.; vessel damaged.

5. *Hermann*, Sept. 3d, lat. 20°, lon. 56° W., severe gale 12 hours: barometer falling as low as 27·30 in. Four other vessels dismasted in this vicinity were reported from one of the Windward Islands; where some heavy weather was experienced at this time. [See note, p. 10.]

6. *Sylphide*, Sept. 3d, lat. 22° 29′, lon. 63°, hurricane; lost topmast, deck load, &c. Two other vessels dismasted Sept. 3d arrived at Havana.

7. *Arve*, night of Sept. 3d, in lat. 22° 30′, lon. 63° 50′, hurricane; disabled and abandoned.

8. *Ocean Bird*, Sept. 4th, [civil time] at 4 P. M. gale increasing from east, with heavy swell, steering south, under double reefed topsails, in lat. 27°, lon. 69°. At 10 P. M. full hurricane from E. N. E.; scudded under bare poles; wind gradually veering round by the north, during the night; hardest gusts from westward; at 4 A. M. Sept. 5th, had got to S. S. W., and hurricane began to abate. During its continuance ran before it, through a curve of eighteen points of the compass.†

9. Brig *Commerce*, bound south, had the hurricane Sept. 5th, from N. E. to S. W., lat. 29° 30′, lon. 69° 50′; was hove on beam ends and dismasted.

* This Journal, vol. ii; 1846: New Series.

† From Capt. Atkinson: The barometer had fallen to 29·10 in the early part of the gale, but was not observed during the period of its greatest violence.

10. *Regatta*, Sept. 6th, lat 29° 20′, lon. 71°, hurricane; veering from N. E. to S. W.; split storm sails; main rail under water three hours; could not be heard four feet, with utmost effort of voice.

11. *Elena*, totally dismasted, Sept. 6th, lat. 32°, lon. 70°.

12. *J. Grierson*, for Gulf of Mexico, Sept. 6th, lat. 31°, lon. 74° 30′, heavy gale from N. N. E., hauling to S. W.; dismasted.——*Caroline*, crippled in heavy blow, Sept. 6th, and put back to Charleston.

13. *Flash*, Sept. 6th, lat. 33° 40′, lon. 76°, hurricane from N. E. to W.; damaged.

14. *Dione*, Sept. 6th, lat. 33° 15′, lon. 77° 20′, hurricane from E. N. E.; lost topsails, top-gallant-masts, &c.

15. *G. W. Lawrence*, Sept. 7th, lat. 33°, lon. 75°, dismasted in hurricane from E. N. E.

16. *Norfolk Packet*, hurricane, Sept. 7th, lat. 33° 50′, lon. 76° 20′; dismasted.

17. *Levant*, dismasted Sept. 7th, lat. 34° 10′, lon. 74° 10′, in a terrific gale from the eastward.——*John Adams*, dismasted in hurricane, 6th–7th of Sept. on south side of gulf stream.

18. *Viola*, dismasted in hurricane, Sept. 7th, near lat. 34° 16′, lon. 73°.

19. *Segesta*, Sept. 7th, lat. 34° 32′, lon. 72° 30′, hurricane, S. S. E. to N. N. W.; dismasted.

20. Steamship *Georgia*;* Sept. 6th, barometer at noon 29·85; lat. 38° 9′, lon. 73° 55′; wind southward, with a large heavy swell from southward and eastward, indicating a blow in that direction; during the night cloudy, with rain. Sept. 7th, [civil time] commences cloudy with fresh breezes from southward and eastward, and heavy cross swell: bar. at 1 A. M. 29·78, 4 A. M. 29·76, wind freshening to a gale: at 9 A. M. bar. 29·45, blowing heavy and sea rising. At noon bar. had descended to 29·10, wind still increasing and sea high; steamer's position about 80 miles E. of Cape. Hatteras; [lat. 35° 14′, lon. 74° 10′]; 1 P. M. bar. 28·40; blowing very heavy in squalls. At 2·30, moderating; 3 P. M. bar. 28·20, wind came out from northeastward, with exceeding heavy squalls; the sea-drift flew across the decks with great fury; no one could withstand its force; at 4 P. M. bar. 28·10, blowing harder than ever, and so continued till 6·30 P. M.; skylights and part of hurricane deck blown away; at 10 P. M. still blowing heavy and sea high: Midnight bar. 29 in., wind still subsiding; and at daylight on the 8th, had abated sufficiently to make sail; 8 A. M. weather moderating. Noon, lat. 35° 40′, lon. 72° 48′.

21. *Rescue*, Sept. 7th, lat. 36°, lon. 74° 30′, hurricane; dismasted.

22. *Albemarle*, capsized in the hurricane at midnight on the 7th, lat. 35° 30′, lon. 73°; all lost except one seaman.

23. *Lyra*, bound south, Sept. 7th, lat. 35° 50′, lon. 73° 30′, hurricane, from E. S. E. to W. N. W.; dismasted.

24. *Fanny*, Sept. 7th, lat. 35° 09′, lon. 71° 39′, hurricane, dismasted. ——*Algorna*, for the Chesapeake, dismasted in lat. —, lon. 70°. [Either the date or the latitude erroneously reported].

25. Brig *Swan*, Sept. 7th, [civil time] at noon, lat. 36° 26′, lon. 71° 44′, had reduced to short sail, gale S. E. by S., and high sea for last

* From reports and memoranda of Capt. Budd.

24 hours; standing south; 2 P. M. heavy gale; furled foresail and hove to; 4 P. M. gale increasing, furled topsail and scud before it under storm stay-sail, then bare poles; 6 P. M. hurricane, E. S. E.; broached to on port-tack; 7 P. M. wind truly terrific; thrown on beam-ends; dismasted about 9 P. M; barometer 28·85: [28 94 as compared with mine], at 11 P. M. force of hurricane began to abate, and before midnight gale had veered to E. N. E. At 4 A. M. Sept. 8th, gale N. N. E. moderating; 8 A. M. stiff breezes; noon, moderate; lat. 36° 13′, lon. 72° 40′.

26. *Star*, Sept. 7th, lat. 36° 10′, lon. 72°, hurricane, from N. E. to W.: dismasted.

27. *Addy Swift*, Sept. 6th, [civil time] fine weather, lat. 37° 20′, lon. 71° 30′, bar. 30·10 in., *a very heavy swell from S. E.*, gradually increasing; wind from S. W. to N. E. Sept. 7th, fine; light winds from N. E.; 8 A. M. bar. 30 in.; at noon, lat. 36° 30′, lon. 71°; wind S. S. E., a double reefed topsail breeze; western horizon very hazy; 2 P. M. cloudy, wind increasing; bar. 29·90; 5 P. M. sails furled, hove to under storm try-sail, gale S. S. E., slight rain, and tremendous sea running; bar. 29·50; [six hours from gale's center]. 7 P. M. severe hurricane from S. E.; at 8 P. M. vessel on her beam-ends, heading within five points of the wind; remained in this position until 10 P. M., when I cut away the mast, and she righted. At 11 P. M. it was almost calm; at midnight the wind came from the west, with increased violence. The wind veered with the sun, that is, from S. E. to West. Sept. 8th at 4 A. M. wind decreasing: at 6 A. M. clear weather and moderate winds. During the heaviest of the gale, the sea was smooth.*

28. *Clarissa*, Sept. 7th, lat. 36°, lon. 70°, severe hurricane from 8 P. M. till next morning, from S. S. E. to S. W.; thrown on beam-ends, with loss of topmast, sails, rudder, &c.

29. *B. L. Swan*, night of Sept. 8th, [nautical] lat. 37°, lon. 71°, hurricane, from E. S. E. going round [probably by N.] to N. W.; dismasted.

30. *Olivier*, Sept. 8th, lat. 36° 37′, lon. 69°, hurricane, from S. W. to N. E.; dismasted.

31. *Octavia*, Sept. 8th, lat. 37° 05′, lon. 68° 04′, severe gale from S. and heavy seas; damaged, and one man lost.

32. *J. W. Buddecke*, dismasted in the gale, and foundered: crew picked up on the 11th, lat. 39°, lon. 65°.

33. *Adrian and William*, Sept. 9th, lat. 39° 50′, lon. 66° 50′, hurricane; dismasted.

34. *Nauticon*, Sept. 8th, lat. 33° 15′, lon. 65°, at daylight gale commenced from S., and increased rapidly: boat's bulwarks and spars swept from the ship.

35. *Bessie Grant*, Sept. 8th, lat. 37° 30′, lon. 63°, in hurricane from N. N. E. was thrown on beam-ends and dismasted.

* Letter from Capt. Berry. Several other captains report a like effect of the most violent portion of the hurricane, in smoothing down the sea. Capt. Berry states, that from 7 to 11 P. M. the cards of his compasses were flying round from east to west like a top; perhaps at the rate of thirty times a minute. When the gale was from the western quarter the compasses were steady.

36. *Revenue*, Sept. 8th, lat. 38° 30′, lon. 64° 48′, at 10 A. M. the hurricane blew all sails from the yards; at 12 30 still increasing; hove on beam-ends at 1·30 P. M., and dismasted; at 5 P. M. hurricane abated.

37. *Liverpool*, near lat. 41° 02′, lon. 68° 23′, Sept. 9th; gale commenced from eastward, blowing hard at N. E. and N. N. E. about four hours, late in the afternoon, and veering westward; barometer at noon 29·20 in. [Estimated as 210 miles to the left of the center path].

38. *Abner Taylor*, Sept. 8th, lat. 39° 30′, lon. 66° 20, hurricane, from S. E. to N. W.; dismasted.——*Georgiana*, dismasted on the 8th, in lat 40°, and abandoned.——*Cairo*, thrown on beam-ends, on southern edge of gulf stream, and abandoned.

39. *Glamorgan*, Sept. 9th, lat. 40°, lon. 65°, hurricane, from E. N. E.; dismasted.

40. *Saragossa*, dismasted in violent hurricane, Sept. 8th, lat. 39°, lon. 63°.

41. *Queen of Sheba*, Sept. 7th, a hurricane, in lat. 39° 50°, lon. 64° 35′, in which lost spars, sails and bulwarks; with other damage.

42. *Juanito*, Sept. 8th, severe gale from N. E., lat. 40°, lon. 64°; thrown on beam-ends and dismasted.——*Tarquin*, Sept. 8th, thrown down in the hurricane, in lat 40°; lost sails, topmast, &c.

43. *Conqueror*, Sept. 8th, lat. 38°, lon. 59°, hurricane; dismasted and filled.——*Haabet*, dismasted Sept. 8th, westward of the Grand Bank; abandoned.

44. *Matchless*, Sept. 8th, lat. 39° 29′, lon. 59° 45′, severe hurricane from south four hours, when it died away and suddenly shifted to the west, blowing very violent; dismasted.

45. *Ionian*, night of Sept. 8th, lat. 40°, lon. 60°, took the hurricane from S.; which shifted to N.; was hove on beam-ends and dismasted.

46. *Henry Harbeck*, Sept. 8th, hurricane commenced at noon from the southward, lat. 40°, lon. 56°. While lying to was struck by a sea, on larboard side, with loss of bulwarks and deck house; five men lost or disabled. At 3 A. M. blowing harder, lost topmasts and sails. Ship foundered.

47. *Tuscarora*, on beam-ends, with loss of sails, &c., in a violent hurricane, Sept. 9th, lat. 41°, lon. 57°, W.

48. *Cadet*, damaged in heavy gale from N. W. Sept. 10th, lat. 43° 30′, lon. 61° 20′ W.

49. *Independent*, Sept. 9th, lat. 40° 20′, lon. 50° 30′, hurricane from S. W. to N. W.; lost topmasts, sails, &c.: at 11 A. M. the hurricane blew with its utmost fury; and the barometer had then fallen to 27·75 inches.*

50. *Wildfire*, Sept. 9th, lat. 42° 04′, lon. 51° 21′, at 11 A. M. under close reefed topsails, wind E., was struck by the hurricane and hove on beam-ends: lost mainmast, topmasts, &c., and one man.

51. *Albert Gallatin*, Sept. 8th, lat. 39°, lon. 48°, severe hurricane six hours, from S. S. E. to N. W.

52. *Charles Humbertson*, Sept. 9th, lat. 43° 16, lon. 45°, in the gale under double reefed topsails, wind suddenly changed from S. to N. without any warning and blew a hurricane; lost sails, &c.

* From the official report and protest of Capt. Smith.

53. *London*, Sept. 9th, squally, with rain; 9 A. M. barometer 29·80: noon, lat. 43° 13′, lon. 44° 12′; at 2 P. M. barometer 29·60; blowing harder; 3 P. M. bar. 29·40, with appearances of a heavy blow; wind S. veering to S. W.; 4 P. M. bar. 29·20; nearly calm, but looked threatening: At 4·30 P. M. bar. 29 inches, when the blast struck us from N. W., like a discharge of cannon; went before it furiously; burst the spencer and sprung main-yard; ship settling away every few seconds as if going down. At 5 P. M. bar. had risen to 29·20; at 6 P. M. the fury of the hurricane was broken, but the gale blew from N. W. through the night; moderating at noon of 10th in lat. 42° 27′, lon. 46°; so that at 2 P. M. we had set fore and main topsails.* [Estimated 165 miles to the right of center path.]

54. *Connecticut*, Sept. 9th, lat. 44° 30′, lon. 47°, terrific hurricane; at 10 A. M. broached to; lost spars and sails, with four seamen; at noon, gale gradually abated; ship lying to on port tack, with head N. E.

55. *Washington*, Sept. 10th and 11th, lat. 46°, lon. 48°, heavy gale at S. S. W., veering round to the northward.—— *Wilton*, from Jamaica, was dismasted in the gale Sept. 10th.

56. *Nathaniel Thomson*, Sept. 10th, lat. 42° 26′, lon. 38°, severe hurricane from S. S. W. to N. N. W. for 12 hours; ship on beam ends for three hours; lost all sails.——*Juno*, for Bremen, had the hurricane Sept. 9th, lost three men: was spoken 13th, lat. 41°, lon. 42°.——*Kezia*, from Mirimichi, encountered it on the 10th, from S. E., with much damage.

57. *Mercury*, Sept. 12th [?], lat. 44°, lon. 41°, took the hurricane from S.

58. *Hibernia*, Sept. 10th, lat. 45°, lon. 42°, hurricane, from N. E. to S. W.

59. *Ossippee*, Sept. 10th, lat. 46° 30′, lon. 42° 30′, very heavy gale from S. E. to N.; split sails, stove bulwarks, &c.

60. *Western Empire*, Sept. 9th, lat. 46°, lon. 36°, hurricane, from S. E. and S. to N. N. E.; lost spars and sails, with other damage.

61. *Sardus*, Sept. 9th [10th ?], lat. 43° 16′, lon. 32° 24′, in a hurricane, lost sails and bulwarks; with other damage.

62. *Burlington*, Sept. 10th, lat. 40° 45′, lon. 29°, severe gale, 16 hours.

63. *John Winthrop*, Sept. 9th, lat. 35° 48′, lon. 29° 30′, severe hurricane, from S. W. to N.; lost spars, sails, &c.

64. *Olympus*, Sept. 10th, lat. 36°, lon. 27°, hurricane, with loss of topmasts, sails, and rigging.

65. *John Dunlap*, Sept. 11th, lat. 46° 15′, lon. 32° 15′, hurricane; lost sails, &c.

66. *Eli Whitney*, Sept. 11th, heavy gale, with damage. Sept. 12th, lat. 47° 19′, lon. 30° 38′, saw *Barbara Ann*, disabled.

67. *Clara Wheeler*, Sept. 10th, lat. 49°, lon. 35°, was thrown on beam-ends, with loss. 11th, gale still continuing, saw a large ship in dismasted condition.

* From Prof. C. U. Shepard, then passenger on the London.

68. ***Robert Kelly***, Sept. 10th, lat. 46° 30′, lon. 31°, hurricane; lost sails, &c.: barometer fell to 28·15 inches.

69. *Rialto*, in the gale, lat. 50° 28′, lon. 35° 43′, shipped a heavy sea, filled cabin, shifted cargo, &c.

70. Brig *Elizabeth*, Sept. 9th, lat. 45°, lon. 29° 30′, heavy gale from S. E. to N. E.; hove on beam-ends while under bare poles; gale abated at 4 P. M. next day.

71. *Stephen Glover*, Sept. 10th, lat. 47° 13′, lon. 30° 16′, hurricane from N. W. and W. S. W.; thrown on beam-ends and dismasted.

72. *Emperor*, Sept. 10th, lat. 47° 30′, lon. 30° 30′, severe gale from S. S. E. to N. W. ending in a perfect hurricane; lost sails, spars, &c.

73. *Royalist*, dismasted in the gale, Sept. 10th, lat. 48°, lon. 30° 30′; abandoned.

74. *Southerner*, Sept. 9th, ended with increasing gale from E. S. E.: 10th, at 4 A. M. gale heavy from N. E.; 5 A. M. a hurricane; 7 A. M. broached to under bare poles; 2 P. M. wind hauled to N. N. W. blowing tremendously; barometer 28·27 in.; 7 P. M. heavy cross sea; 10 P. M. 7 feet water in hold: at 11·30 P. M. crew took to the boat. Sept. 11th, at 6·30 A. M. ship went down head foremost, in lat. 47° 15′, lon. 30° 24′.

75. *Caroline*, Sept. 10th, lat. 48° 12′, lon. 30°, gale commenced in heavy squalls from E. S. E., soon hauling to different points of the compass, and blowing a hurricane; laid six hours under bare poles; the furled canvass blown from yards, with other damage.

76. *Harvest Queen*, severe hurricane Sept. 10th, lat. 47° 10′, lon. 29° 30′; from S. S. W to N. W.

77. *George Hulburt*, for Havre, violent gale Sept. 10th, between lat. 48° and 49°; lon. 30°; was hove down and lay many hours on port-side.

78. *Palermo*, Sept. 10th, lat. 49°, lon. 31°, in hurricane from S. E., decks swept, with loss of the mate: gale continued next day from N.W.; in lat. 48°, lon. 30°. On three following days strong winds from S. W. to N. W., to lon. 18°.

79. *William Hitchcock*, lost sails, &c. in the hurricane from W. S. W. Sept. 10th, lat. 46° 30′, lon. 27°.

80. *Devon*, in violent gale, under bare poles, Sept. 12th [?], lost spars, bulwarks, binnacle, &c. &c.; lat. 46° 33′, lon. 26° 40.

81. *Victoria*, dismasted and water-logged in terrific gale from westward, Sept. 10th, lat. 47° 17′, lon. 27° 09′.

82. *Chesapeak*, Sept. 10th, lat. 47° 10′, lon. 27° 30′, severe hurricane from S. E. to N.; received much damage.

83. *Metropolis*, Sept. 10th, lat. 47°, lon. 26°, gale from S. W. to N. W.; dismasted.

84. *Josephine*, hurricane, Sept. 10th, lat. 47° 01′, lon. 24°.——Next day, passed *Lady Seymour*, dismasted.

85. *Larpool*, Sept. 11th, lat. 48°, lon. 25°, heavy gale; on beam-ends four hours, with much damage; barometer, 28·52 inches.

86. *Solway*, abandoned Sept. 11th, lat. 48° 30′, lon. 24° 30′, at 9 A. M: wind then heavy from N. Was wrecked the day previous in the gale.

87. *Alexina*, hurricane, Sept. 11th, lat. 46°, lon. 22° 50′; hove on beam-ends, with much damage.

88. *Brown*, Sept. 10th, lat. 49° 45′, lon. 25°, lying to with strong gale from S. E.; about 4 P. M. it fell dead calm for about half an hour, while rain fell in torrents; at 4·30 a sudden gust came up from the west, and continued to blow a perfect hurricane; ship hove to under bare poles, and leaking badly: 8 P. M. hurricane as violent as ever. At 1 A. M. vessel fell over and was dismasted; crew taken off on 16th.

89. Barque *Elizabeth*, at Quebec, reports; Sept. 11, lat. 47° 56′, lon. 22° 07′, experienced a hurricane from S. W. which proved to be a revolving storm. At midnight, wind veered from W. to W. N. W. At 2 A. M. being most violent, it blew away the close reefed topsails. The ship being laid to with head to the southward, escaped the vortex.*

90. *Avalanche*, Sept. 10th, lat. 48°, lon. 20° 15′; at 4 P. M. [civil time] gale very severe at S. S. E.; brought the ship under a single topsail; [bound west] at 5 P. M. barometer 28·50, was struck with a heavy gust from N. W., and thence twice round the compass: 6 P. M. lying to under bare poles, barometer 28·70; gale, after the crisis, mostly N. N. W. by compass. [N. W. nearly.] Sept. 11th, at 8 A. M. wind N. W., and so far moderated as to allow a close reefed main-topsail.†

91. *Rufus K. Page*, in the gale, Sept. 11th, lat. 39°, lon. 17°, was struck by a heavy squall from the northward and dismasted.

92. *Barque Swan*, from Lisbon, Sept. 12th [?], lat. 36° 50′, lon. 15° 25′, severe gale from E. N. E. round by S. to N. W.

93. *William Ray*, Sept. 11th, lat. 49° 10′, lon. 20° 30′, hard gales; at 4 P. M. furled all sails and hove to, in a mountainous sea; midnight, dreadful sea, ship lay on her broadside; 6 A. M. got before the wind under double reefed fore-topsail; water-logged; abandoned on 14th. The gale veered from S. by the W., to W. N. W.

94. *Euterpe*, Sept. 9th, lat. 48° 42′, lon. 19° 30′, severe hurricane, which came on at S. E. and abated at N. W.

95. *Esther G. Barney*, severe gale Sept. 10th, lat. 48° 04′, lon. 18° 36′; threw over part of cargo.

96. *Nicholas Biddle*, lat. 52°, lon. 19°, dismasted Sept. 14th [?], while lying to in a gale from N. N. W.

96 *a*. R. M. steamer *Andes*, severe gale, S. S. W. veering to N. N. W.; lat. 51° 30′, lon. 18° 30′; barometer 28·48.

97. *Constantine*, lost sails, top-gallant-masts, and sprung fore-topmast in the gale from W. S. W., Sept. 14th [?], lat. 52° 34′, lon. 17° 30′

98. *Devonport*, took the gale Sept. 10th, lat. 54°, lon. 22°; continued till 6 A. M. of 12th, with heavy sea.

99. *Commerce*, lost spars and sails in the gale, Sept. 10th, lat. 48° 53′, lon. 13° 40′.

100. *Mary Glover*, in gale from S. W., Sept. 11th, lat. 50°, lon. 14°, lost mainsail, with other damage.

101. *Susan & Sarah*, Sept. 11th, lat. 55° 20′, lon. 15° 30′, in severe gale from S. W. was hove on beam-ends; lost mizenmast and one man. Returned to port.

* It too often happens that ships, when running westward in a southerly gale in these latitudes, and being thus in the right side of the storm-path, are hove to unwittingly on the *port-tack;* perhaps as more convenient, or with a view to avoiding some loss in distance. Of the increased danger of this tack, *when in the right side of the storm-path*, in the northern hemisphere, every navigator should be informed.

† Statement of Capt. Leach.

102. *Anne*, from Orkney, for Limerick, lost bulwarks in the gale, with sundry other damages; was as far as lat. 55° 20′, lon. 10° 15′ W.; hove-to for sixty hours, and drifted off Tory Island; never experienced such a sea.——*Neptune*, with loss of foremast, was passed Sept. 13th, lat. 50°, lon. 25° 40′.

103. *Zanoni*, from Greenock; Sept. 11th, lat. 57°, lon. 15°, heavy gale; sprung a leak, and was abandoned. This position is on the Rockall Bank.

104. *Virginia*, from Gothenburg, Sept. 12th, [naut.?] in lat. 60° 40′, lon. 11° 34′, encountered a heavy gale and was struck by a heavy sea which caused the ship to leak: in continuance of the bad weather, lost topmasts, and bore up for the nearest port. Had good weather previous to this gale.*

The master of an English brig who was off the Lands End of Cornwall in this gale, reported to Capt. Leach of the Avalanche that its strength was only sufficient to bring him to two-reefed topsails.

At Scilly, Sept. 10th, wind S. S. E. to S. W. fresh, with heavy rain; bar. 29·50: Sept. 11th, wind S. S. W., fresh, with rain; bar. 29·70, to 29·75.

At Holyhead, 70 miles west of Liverpool, Sept. 10th, wind E. to S. E., fresh: 11th, S. W., hard gale and squally.

On the western coast of England and coast of Ireland, the exterior portion of this cyclone set in from the eastern or southern quarter, and veered to the westward as the body of the storm passed on to the northward; with "a very heavy ground sea on the coast."

At Tobermory, I. of Mull, lat. 56° 37′, lon. 6° 04′ W., Sept. 11th, A. M., a heavy gale from N. E.: evening more moderate. The variation being 28¾° W., shows the wind at N. 6¼° W., true. In view of the trending of the strait and the high land along its northern opening, this may consist with an outside gale from N. N. W.

The foregoing accounts show the right border of the storm to have extended to the shores of England; but in no extraordinary force, and with a depression of less than half an inch in the barometer: while the axial area, with the more active portion of the cyclone, appears to have passed over the Rockall Bank or on a center-path still more distant from the British Islands, in its course toward the polar basin. See Track XXIV on the Chart.

In reviewing the daily progress and phenomena of the storm, it should be recollected that most of the sea accounts are given in nautical time, and thus are often one day in advance of the calendar. The direction of the winds being given by compass,

* The whole number of vessels noticed in the foregoing reports, is 125; of which 104 are seen to have reported their several positions at the time of the gale, or the same is otherwise indicated. I have a further list of 17 vessels, lost or disabled in the gale, making an aggregate of 142 vessels reported. Of these, no less than 75 were lost or dismasted; and 46 were crippled, or damaged: while of the remaining 21, no report of injuries was made.

Of this vast series of disasters, not one was occasioned by rocks, shoals, or a lee shore. The fate of a far greater number of vessels (probably of less commercial value,) which were doubtless exposed in this gale, cannot now be ascertained.

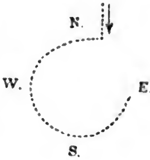
a correction of ten to thirty two degrees is required for the westerly variation, from off Georges Shoals to the Rockall Bank, and the shores of Europe.

The first report in the above series is important, viewed as the earliest notice, and as from a region long supposed to be free from hurricanes and gales; of which more hereafter.

The commencement of the gale at N. E. with the *Independence* (2) marks nearly its center-path. On carrying back the trace-line derived from this and subsequent reports, it appears that the *William Money* (1) was north of this line, in the right side of the gale, as relates to its course of progression. The Independence was also on the right of the center-path, during the middle and latter part of the gale, as is shown by the veering of the wind: both vessels being bound northward. The positions reported, are probably those of the noon immediately preceding the onset of the gale.

The *Hermann* (5) was bound southward. Hence her final position in the gale was probably more southward than that reported. The remarkable fall in her barometer showed a position near to the axis of the storm.*

The *Ocean Bird* (8) first encountered the gale at E. N. E., which places her in the right-front of the storm. Had she then hove to on the starboard tack, the wind would have veered by the east, as with (2); but steering south, and then scudding before the wind during the night, she crossed the center-path and ran partly round the axis of rotation; and had the gale been slower in its advance, she might thus have completed an entire circuit. This case of running with the wind, with another which I shall adduce, may be of interest to some who think we have not shown the wind's rotation.



The rate of advance appears to have lessened as the storm approached the line or axis of equal diurnal motion; the position of which, on this occasion, appears to have been somewhat above the 30th parallel of latitude.†

* In the New York Daily Times, I find a letter of which the following is an extract; which, with an obvious correction, probably gives the true place of the Hermann in the gale:——"St. Thomas, Sept. 19, 1853. On the 4th, the barometer fell, and the wind was fresh from the North, giving rise to some apprehension that a hurricane was at hand. But it was only the wind from the wings of one passing just to the north of our island. The Danish bark *Hermann* encountered it on Sept. 2nd, lat. 53°, and lon. 18°, [obviously *lat.* 18°, *lon.* 53°]. On the 4th, it had arrived to the northeast of us, where the French brig *Diamond*, and the American brig *Carlton*, from Boston, and the schooner *Ann Maria*, from Baltimore, struggled with its fury. Col. REID's Theory, or rather Mr. REDFIELD's Theory of the gyratory movements of these storms, can no longer be doubted. A vessel was seen by the *Diamond* on the 4th, dismasted."

† From the physical relations between the diurnal rotation of the earth's crust and that of the immediately incumbent atmosphere, which result from the inertia

The progression of the gale, as in former cases, appears to have been greatly accelerated after it passed the axis of equal diurnal motion, on its recurvated course through the temperate and higher latitudes. The following estimates are roughly made, by setting off the progression on the Chart, as shown in trace XXIV, reckoning in English miles, at seventy for a degree of the meridian.

From a point opposite the position of the William Money (1) to that opposite the Hermann (3)

		Hours.	Miles.	Av. per hour.
Say,	- - - -	84	1942	22
To position of	Ocean Bird (8)	50	980	19·6
"	Georgia (20)	62	814	13
"	Addy Swift (27)	7	175	25
"	Independent (49)	36	1102	30·6
"	Avalanche (90)	30	1505	50
"	Virginia (104)	15 (?)	758	50·6 (?)
		284	7276	

and unstable mobility of the latter, the great storms of the inter-tropical regions must necessarily have a westerly progression; the rate of which denotes the existing difference of the diurnal motion. It is shown also by numerous investigations of these storms, that their westwardly movement as integral portions of the lower atmosphere, is united, in most cases, with a constant movement *from the equator.* Hence the relative movement becomes northwesterly; and is continued until the storm reaches a parallel of latitude where the diurnal motion of the earth's crust and that of the lower incumbent atmosphere are equal. This line, or belt, I call the axis of *equal diurnal motion.* It often marks the exterior limits of the trade winds; and its position is found to vary at different times, and in different seas or regions: good examples of which are found in the several points of recurvation seen in the storm-tracks on the Chart. On crossing this axis, the diurnal motion of the lower atmosphere is found to exceed that of the earth's surface, and produces a relative movement from the west, which, combined with the continued movement from the equator, determines the route of the storm through the temperate latitudes.

This prevailing tendency or movement from the equator, in the inferior strata of the atmosphere, is equally developed in the temperate latitudes, at all seasons of the year. It is probably due to the general gravitation of the atmosphere, acting counter to the centrifugal effect of the earth's rotation: for the latter force, owing to the greater axial radius, is necessarily greatest in the higher atmosphere, in regions beyond the cognizance of our observations.

In those cases where the easterly and westerly currents of rotation are less active, or in other words, when the diurnal motion of the lower atmosphere is least unequal to that of the earth's surface, the alternate westerly and easterly progression of the storm becomes greatly modified, in degree, though subject to the same general law of planetary dynamics. This may be seen exemplified on the Chart, in tracks VII, XIX, XX, and Col. Reid's Bermuda hurricane, of Sept. 1839. This dynamical law governs the progress of all cyclones, however gentle in their rotary action; and necessarily applies to the general movements of the lower atmosphere.

The *lower atmosphere*, in my apprehension, includes all that portion of the atmosphere in which the direction of its currents can be discerned by means of natural phenomena; and, in the largest sense, with an upper limit not higher than is indicated by a pressure of fourteen inches of the barometer. In a more restricted sense, I would apply it to the lower winds and currents so far only as to include an elevation of four thousand, to six thousand feet above the surface. The latter will prob-

Thus we have an estimated distance of 7276 miles, traversed by the storm in about twelve days: at an average rate of progression of nearly 26 miles an hour.

The slower rate of progression at and near the axis or belt of equal diurnal motion, accords with results ascertained in my previous inquiries, and with those severally shown by REID, THOM, and PIDDINGTON, in the gales of the Southern Ocean and the Asiatic Seas.

In my approximated delineation of the axis line or center-path on the Chart, I have had reference to the path of greatest violence, where observations were had from both sides, and especially to the opposite veering of the wind, which is found in the opposite sides of an advancing cyclone. Northeastward of Cape Hatteras, we find the storm-center to have passed between the *Georgia* (20) and the *Swan* (25) on one hand, and the *Addy Swift* (27) on the other.

The incurvation of the storm-path toward the Azores is quite remarkable. This feature I first noticed in the case of the storm of Sept. 1846, as shown by observations extending to lat. 62° 30′, far beyond the limits of my former map, on which its track (XIX) was first delineated. This tracing, with that of the hurricane of August 1851, (XXII) has been copied on this Chart, and extended without further alteration. The number and extent of the reports obtained in the present case, have induced me to delineate this feature more fully than I first intended. Its probable relation to the expansion and perhaps the falling off of the southern portion of the cyclone toward the equator, may be considered hereafter.

Eastward of the Grand Bank, nearly all the reports are from the right side of the storm-path, and so far as appears, mostly at great distance from the true axis path of the gale. This may be owing to the diminished violence of the two left quadrants of the cyclone, caused by its accelerated progression, as well as to the paucity of reports from the more northern portions of the Atlantic, which are less frequented by navigators. That the cyclonic nucleus of the storm had become greatly enlarged, and that it pursued the general course I have indicated, appears from its wide-spread violence, and the intensity and wide extent of its influence on the barometer, and, especially, by the most northern reports. From these few northern reports, we see this violence

ably include the entire volume of all our great storms; except on high table lands or in mountainous localities.

But as regards the movements in the upper atmosphere, in regions higher than the limits first mentioned, almost nothing appears to have been yet learned; although inferences, urged with great confidence, have been sufficiently common. These inferences may be as variant as the hypotheses on which they are founded; and seldom appear reconcilable with visible phenomena, if these be widely and carefully considered.

extended beyond lat. 60°, in the general direction of the Feroe Islands, and the main entrance to the Arctic Sea.

In other cases we find, that after passing the latitude of Bermuda, the expansion of the storms is often so great that their southern portions advance nearly from west to east; but reach the successive meridians no sooner, and sometimes even later than the axial portion of the gale, which pursues a more northeasterly course. Thus in the present case, east of lon. 60°, and between lat. 35° 30′ and lat. 42° 30′, a belt of seven degrees, we have a series of thirteen observations, carrying us east to lon. 15° 25′, in lat. 36° 50′; almost to the southwestern extremity of Europe. See reports 43, 44, 46, 47, 49, 51, 56, (including *Juno,*) 62, 63, 64, 91, 92. If, instead of the broad range of our present inquiry, we were limited, as in the United States, to fewer parallels of the temperate latitudes, how readily might an east progression of the storm be shown, by these partial observations, and its true course remain unnoticed.

But I apprehend this southward expansion of the storm to have been due to something more than the centrifugal force of the cyclone, acting against the statical pressure of the circumjacent atmosphere. In such a wide-spread cyclone, whose diameter on the 9th of September extended from Newfoundland,* to beyond the Azores, or more than 1500 miles, how could its vast entireness be much longer maintained, against both the centrifugal and gravitating forces of the earth, acting in opposite directions, and with opposite degrees of effect, or predominance, on the sides respectively nearest the equator and the pole? May we not suppose that the southern portion of the gale was in process of separation or falling off toward the equator, and thus supplying the influx which sustains the inferior trade winds in northwestern Africa and the eastern Atlantic? And is not such a view supported, in some degree, by the gradually altered course of the nucleus of the storm, which in becoming more free from the equatorial influence, is left to pursue its course toward the polar basin under the predominating influence of direct gravitation?

In reference to these questions, it may be stated that the Steamer *City of London*, in her passage from the Mediterranean, where she had fine weather, left Gibralter Sept. 11th, and encountered strong gales from N. E. with heavy sea; arriving at Southampton on the 18th;—thus showing a brisk movement of the winds, at this period, toward Madeira and the lower latitudes.†

* Through the kindness of R. Dinwiddie, Esq., I am in possession of observations made at Harbor Grace, in Trinity Bay, N. F., lat. 47° 40′, lon. 53° 16′, which show that the left margin of the storm touched that place Sept. 9th, with a stiff wind from N. E., and cloudy.

† Taking into view the greatly diminished force of this gale at the entrance of the English Channel, and that we have no notice of its action in the Bay of Biscay, while we trace its violence *continuously* from off Cape Hatteras to the Rockall Bank and beyond lat. 60° on one hand, and to lat. 36° 50′ and lon. 15° 25′ on the other, with all the characteristics of a severe gale, I confess that some solution like the

EFFECT OF THE STORM-WIND ON THE BAROMETER.—The unfailing mechanical effect of the cyclonic wind in producing a fall of the barometer within the area of its circuit, and greatest in the axial region of the cyclone, is clearly seen in this storm. The following are the cases reported in which the barometer fell below 29 inches: to which I have annexed a rough estimate of the probable distance of the vessel from the axis of the storm at the time of nearest approach.

	Minimum of Barometer. Inches.	Supposed distance from gale's axis.
Hermann (5)	27·30	*near.*
Georgia (20)	28·20	45 miles.
Swan (25)	27·94	30 "
Independent (49)	27·75	220 "
Robert Kelly (68)	28·15	265 "
Southerner (74)	28·27	240 "
Larpool (85)	28·52	315 "
Avalanche (90)	28·50	430 "
Andes (96 *a*)	28·48	280 "

From observations of the barometer and winds taken at various points in the United States near the Atlantic coast, and from those made at the signal station in Bermuda, it appears that the storm was but little felt at the latter place, except as exhibiting the true cyclonic wind, from 6th to 8th, from S. E., veering gradually from S. E. to S. W., as the bearing and progression of the storm became changed; with a force of wind marked from 2 to 4; the barometer at 30·10, at noon of 5th, 6th and 7th and 30·07 at noon of 8th. The left side of the storm encroached to some extent upon the eastern borders of North Carolina and Virginia. At Scuppernong, N. C., lat. 35° 50′, lon. 76° 20′, the cyclonic wind blew from N. E., with a force marked 3 and 2, with rain; and the lower stratum of clouds [the true storm-scud or cyclonic stratum] flew rapidly from N. E.; *the upper clouds quite still.* At 9 P. M., the wind had veered to S. W. No observations of barometer. At Fort Monroe, Va., the reported direction of the storm-wind and cloud, are the same as at Scuppernong, with rain from S. W. at 9 P. M., with thunder and lightning.

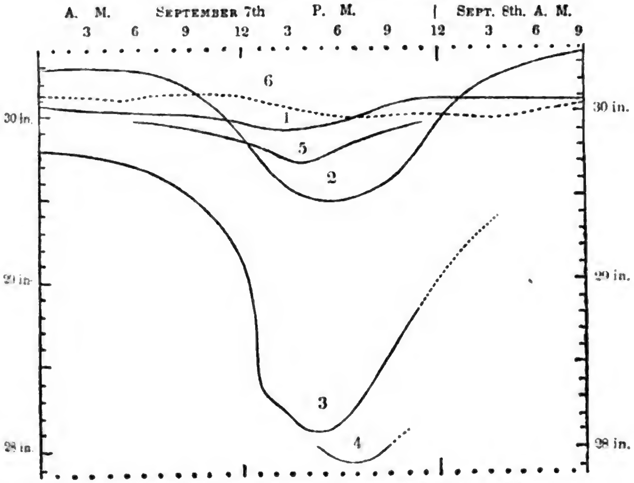
At Savannah, on the 5th and 6th, in front of the storm, the maximum of the barometer was 30·20, and 30·19; on the 7th, the minimum of the report is 30·06, and on the 8th, under the rear portion of its annular wave, 30·21. At Jacksonville, East

above is apparently required. The normal course of the circulation, or of the "current of rotation" in the basin of the North Atlantic, between latitudes 10° and 50°, as well as the routes taken by some storms which have recurvated in low latitudes, clearly indicate that a part of the out-moving atmosphere, from the inter-tropical latitudes, in the western Atlantic and the Mexican Gulf, moves in an elliptical circuit, and returns to the trade wind in the eastern Atlantic. This apparent tendency in storm-routes is seen in Col. Reid's track of the great hurricane of Barbadoes in 1780, and in my track XV, on the present Chart; also in track XIII of my former Chart, which is better seen on Chart III in vol. i of this Journal, New Series.

Florida, nearly the same: as also at Charleston, S. C., nearer to the path of the storm; and scarcely falling below 30 inches at New York and Nantucket, as the storm passed. But at Camden, S. C., 140 miles N. N. W. of Charleston and 280 miles W. S. W. of Hatteras, the successive maxima on the 6th and 8th were only 30·04, and 30 inches; showing this place to have been beyond the crest of the external barometric wave. When storm-tracks recurvate on the interior meridians of the United States, the minimum depression of the barometer frequently moves nearly parallel to the direction from Camden either to Hatteras or to Chesapeak Bay.*

The annexed diagram shows the barometric curve at Washington, Fort Monroe, steamer Georgia, and Bermuda, while the storm was passing between the latter and Washington. These two places are distant from each other about 840 miles; which perhaps may be considered as an approximate measure of the *barometric* diameter of the storm on the 7th of September. The barometric curve of the *Georgia*, if increased so as to reach the minimum of the *Swan*, may represent a section through the center of the cyclone, in the direction of the storm's progression.

Storm-Curves of barometric progression.



1. Curve at Washington: 2. at Fort Monroe: 3. Steamer Georgia: 4. Brig Swan: 5. Ship Eagle, crossing in front of storm: 6. Bermuda.

* I am indebted, on this occasion, to the officers of the Smithsonian Institution, and to Gen. Lawson, chief of the medical bureau at Washington, for observations from various parts of the United States; also to Lieut. Maury, Supt. of the Naval Observatory, for abstracts of the logbooks of Ship Eagle, and steamer Northern Light, Surgeons Williamson and Harrison of the Navy, and many ship-masters, and others, have kindly aided my inquiries.

It will be seen that the above diagram includes a period of thirty-three hours; and if we rate the progression at twenty-five miles an hour, it will comprise a distance of 825 miles. It contains the curve derived from observations on board the ship Eagle. I add the following condensed statement which is derived from the abstract of the ship's log sent me by Lieut. Maury.

The clipper ship *Eagle*, Warren, from Rio, crossed the center-path on the morning of Sept. 7th, perhaps 350 miles in front of the axis of the gale, while running in the direction of Cape May. It is interesting to find that this vessel, which crossed the equator Aug. 17th, was overtaken by the external barometric wave of the storm as early as 4th–5th of Sept., and by *a long swell coming up from S. E.;* being then from 100 miles to 60 miles southward of Bermuda. Through the 6th, winds from southeast quarter, veering to South, with *a heavy swell from S. S. W.;* latitude at noon 34° 39′, lon. 69° 32′; bar. 30·11. Sept. 7th, *a very heavy swell from S. S. W.;* wind fresh, from S. S. E. to S. S. W.; and from S. S. W. back to E. N. E.—bar. at 8 A. M. 29·90, at noon, 29·84 in. lat. 37° 17′, lon. 72° 28′: P. M. very threatening appearances from S. E. by S. to S. W., with *a very heavy swell from S. W.;* at 4 P. M. bar. 29·70,—at 5 P. M., 29·77; wind fresh from E. N. E. to N.; 8 P. M., lightning at N. W.; at 11 P. M., in a heavy squall, wind shifted to N. N. W.; no rain; heavy sea still.——Sept. 8th, cloudy; no sea; lat. at noon, 38° 38′, lon. 74° 13′; bar. 30 inches.

The steamer *Northern Light*, bound for the Isthmus, was several hours ahead of the *Georgia*, and on a more eastern track. She crossed the center-path in front of the gale, and ran through its eastern side.——Sept. 7th, lat. 34° 30′, lon. 73° 25′; through the day, strong gales from the South; with a heavy sea from S.W.——Sept. 8th, lat. 32° 01′, lon. 73°, strong gales from S.W., with heavy squalls, and *a large sea from W. N. W.:* Clear in the S. E., with stormy appearances in the N. and W.:——found the weather improving as we made south.——This account is probably in nautical time.

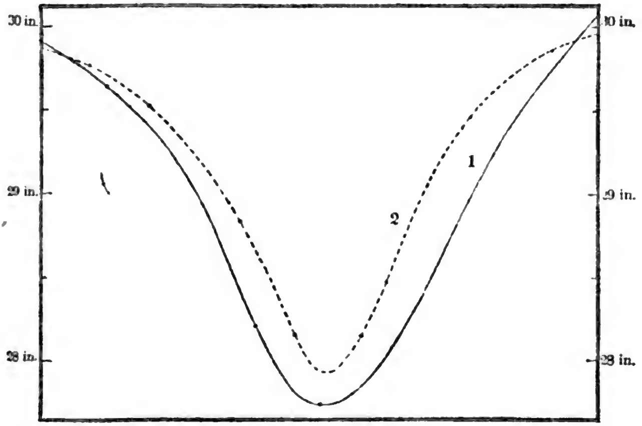
The succeeding diagram represents, in its horizontal scale, the distance of 840 miles between Washington and Bermuda. The full line (1) represents, approximately, the barometric curve through the center of the storm, *transversely to its path.* The comparison of this transverse curve with the central curve of *progression*, indicated on p. 18, is of some interest; although we have no observations intermediate to the Swan and Bermuda. The resemblance of the two central cross-curves may show that the storm was of nearly equal extent and force on all of its sides, at that time.

I have been apprehensive of a clerical error in the barometric report from Fort Monroe for 3 P. M. and 9 P. M. of Sept. 7th; and that 29·063 and 29·087, should have read 29·63 and 29·87, respectively. In preparing the second diagram I became convinced

that the correction is required; and have accordingly applied it, in tracing the transverse curve: but have drawn a short trace line to show the observations as found in the report.

I have also inserted in this diagram, in broken lines, the transverse barometric curve through the center of the Cuba hurricane of October, 1844; when in nearly the same geographical position. This curve is approximated from twenty-eight observations in the path of that storm.

Barometric Storm-Curves, transverse to the Progression.



1. Transverse centre-curve of Cape Verde and Hatteras hurricane, Sept. 7, 1853.
2. Transverse center-curve of Cuba hurricane of 1844, Oct. 6th.

Vortical Rotation of the Gale.—The true character of this gale as a cyclone, is made evident by the foregoing series of observations. This is most extensively shown by the various observations made on all sides of the storm during its passage between Bermuda and the nearer portions of the United States. The absolute whirlwind movement of the storm stratum, and the increasing rapidity of its leftwise rotation which is found in approaching the axial area, from whatever side of the storm, as well as the direct effects of this increased rotation on the fall of the barometer, in the interior portions of the gale, are made manifest by direct observation. This I might point out in full detail, were it at all necessary in the present stage of the inquiry. Nor can these results be evaded by denominating any one portion of the cyclonic wind, on either side of the cyclone, as another or distinct gale. The local variations and inequalities of the cyclonic action and the errors, imperfections or defects which may exist in the reports, are alike overborne by the amount of evidence

which serves to show the extent and general entireness of the vortical rotation in the gale.*

It would be an error to suppose that the gales and hurricanes which have been traced on our storm charts, were but exceptional cases of cyclonic action and progression in the winds of our globe. For there is a constant succession of rotary movements, greatly variant in their activity and their visible effects, and to which I shall further allude. It is the more violent cyclones, however, that afford us complete evidence of their geographic routes and their continued movement of rotation.

Of this active class, designated as hurricanes, gales, and storms, it is believed that the tracks or routes of several hundred might be added to our storm maps, by carefully collating the records which already exist. It is certain that a large number might be traced from the records and notices now in my possession or otherwise at hand; of which, the case I have now presented is but a single example. But the storms noticed in the succeeding portions of this article are selected in reference to their peculiar localities, as showing the uniform extension of the cyclonic system in equal latitudes around the globe, rather than for the amount of information possessed, regarding their extent and progression.

(To be continued.)

Art. II.—*Account of a Rainbow caused by Light reflected from Water;* by Prof. E. S. Snell, of Amherst College.

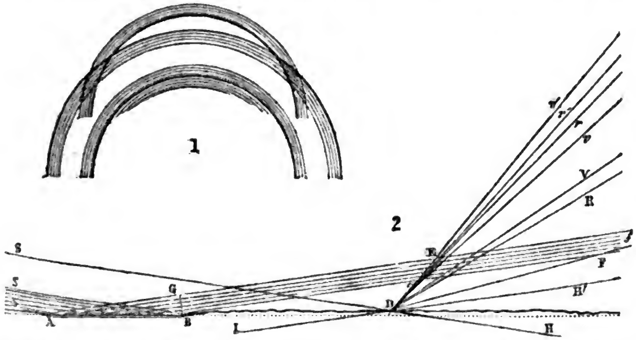
I have received from my friend and former pupil, Mr. H. M. Adams, of the Theological Seminary in East Windsor, Conn., a very interesting description of a brilliant rainbow scene, witnessed by himself and others, on the 24th of Sept. last. After a slight shower, the sun shone out, about 5 P. M., and produced the usual primary and secondary bows, except that they were of uncommon brightness. Four or five supernumeraries, exceedingly vivid and beautiful, underlined the upper part of the primary, the usual attendant of a very brilliant rainbow. In addition to these, there was seen an excentric bow, quite as luminous as the secondary, but in angular size and order of colors, just like the primary, and

* While the printing of these pages was in progress I received from the government of Denmark, through Consul Bech, observations made at Oefjord, on Skage Strands Bay in the north of Iceland, in lat. 65° 40′ N., lon. 20° 40′ W.; which show the maximum pressure in advance of the cyclone to have been 29·75 in., at 1 P. M. Sept. 10th, under an east wind, the force of which is marked 2. The fall of the barometer under the cyclone continued till the night of 12th; the lowest observations being 29·12 in. at 10 P. M. of 12th, and 29·11 in. at 6 A. M. of 13th. The wind was S. E. on the 11th and 12th, and, on the rising of the barometer, was followed by the N. W. wind of the cyclone on the 13th, which afterwards changed to S. W., its force being marked 1. The normal effect of the cyclone at Oefjord, a position which is remarkably sheltered from the force of the cyclonic winds, by the peculiar outline and the extensive elevations of Iceland, is deserving of notice; not taking into account the modified direction and the abatement of force which appears to occur in the left quadrants of the gales in this highly northern portion of the Atlantic.

vertex 4° above it. Its extremities came within 15° of the horizon, and if prolonged a little, would have intersected the primary itself. This gorgeous display lasted some ten minutes, when the third bow began to fade at the top, and soon wholly disappeared. (See Fig. 1.)

Mr. Adams rightly judged that this additional bow was the effect of the sun's rays, reflected from the Connecticut river, which runs on the west side of the Seminary hill, and whose waters were then very placid. It was in fact a primary bow produced by an image of the sun in the river. As the vertex of the reflected bow was 4° above that of the secondary, or 16° above that of the primary, the image of the sun must have been 16° below the sun itself, and the sun therefore 8° above the horizon. In first considering the case, I found it difficult to conceive, that the stratum of light, reflected so obliquely from a narrow belt of water, could have sufficient thickness to form a bow occupying between 160° and 170° of a circle.

The accompanying vertical section through the axes of the bows, exhibits in their true proportions, the breadth of the river, the distance and elevation of the observer, and the thickness of the reflected sheet of light; and shows pretty accurately what



must have been the situation of the drops concerned in producing the upper and lower parts of the bow. (See fig. 2.) The breadth of the river, AB, is a little more than half a mile. The observer at D, is elevated 100 feet above the level of A B, and his distance from B, the nearest bank of the river, is three-fourths of a mile. S D H is the axis of the direct bows, inclined 8° to the horizon. The axis of the reflected bow, I D H′, intersects S D H at D, making with it an angle of 16°. A B E F is the reflected sheet of light which penetrates the shower and forms the image-bow. Its thickness in the section G B, measures about 370 feet. R D, V D, making with D H the angles 40° 17′ and 42° 2′, are the red and violet rays from the summit of the primary bow; *v* D, so much elevated, as to cross the secondary, and extend at the

r D, in like manner, mark the top of the secondary, making with D H respectively the angles 50° 59′, and 54° 9′; while *r′* D, *v′* D, are drawn so as to make the angles 40° 17′ and 42° 2′ with the axis of reflected light, I D H′. These last rays must come from drops occupying the space E *e*. D F is next drawn, at an inclination of 15° with the horizon, that being the estimated height of the extremities of the image-bow. This line, piercing the luminous stratum in F *f*, indicates the position of the drops which produced the lower portions of the bow. D E, representing the distance of the remotest drops, which could reflect the summit-rays to the eye, is about one-half of A B, or one-fourth of a mile; and these drops, if falling perpendicularly, would reach the ground within 900 feet of the observer. But the lowest rays, vertically projected in F D, must come from drops, whose least distance from the eye, is $\frac{\mathrm{D\,F}\cos 7^\circ}{\cos 42^\circ\, 2'}$; since F D is 7° above the axis D H′. Now D F in the section is about equal to D B, or three-fourths of a mile. Hence the ray, whose vertical projection is D F, is $\frac{3}{4}$ m. $\times \cos 7^\circ \div \cos 42^\circ\, 2' =$ one mile in length, very nearly. The lines, B G, D E, and D F, may be readily calculated, and will be found to accord nearly with the above values. It appears, then, that the drops forming the top of the bow, cannot fall at a *greater* distance than 900 feet, while those forming the lower ends, cannot fall *nearer* than 5200 feet.

How can we account for what at first view seems to be true, that the light already somewhat enfeebled by reflection from the river, should be able to penetrate more than 4000 feet into the shower, and then return through the same 4000 feet of rain, and yet reach the eye in sufficient quantities to exhibit brilliant colors? I apprehend that this part of the phenomenon can be explained only on the supposition that several favorable circumstances conspired to produce a remarkable result.

1. The air was undoubtedly so clear that the sun shone with intense brightness. The extraordinary brilliancy of the bows, and the number and vividness of the supernumeraries, are a sufficient proof of this.

2. The shower was probably not very dense; so that the rays could penetrate into it much farther than usual, and return again to the eye.

3. A more important favoring circumstance than any other, perhaps, would be a convexity toward the observer of the nearest outline of the shower; so that, while rain was falling within 900 feet of him in a direction precisely opposite to the sun, and thus near enough to form the top of the bow, the nearest rain, on the right and left, where the extremities were seen, might be 5000 or 6000 feet distant. If the light was intense, and the drops sparse, then a much less degree of curvature might be attended with the same result. In the present instance, there can be little doubt,

I think, that the western limit of the shower was more or less convex towards the point of observation.

4. If the river bends eastward at all on the North and South of the observer's position, this circumstance would virtually add so much to its width, since the rays forming the branches of the bow would then fall lower than B F in the vertical projection. Whether this is so, I am not informed.

It is obvious from an inspection of the figure, that most of the reflected bow would disappear sooner than the direct bows, inasmuch as the angular thickness of the luminous stratum, at its intersection with the shower, would rapidly diminish as the shower retired. And, furthermore, as the vertex was produced by the nearest drops, this part must have vanished first, as was observed to be the fact.

Had the sun been about 6° above the horizon, the vertex of the image-bow would have coincided with that of the secondary; and by its opposite arrangement of colors, would have partially neutralized its tints, and made a white segment common to the two. It was in this aspect that the direct and reflected bows presented themselves to the view of Dr. Halley, in 1698, on the bank of the river Dee, of which he published an account in the Transactions of the Royal Society.

To the inquiry, why do not those, who live near a sheet of water, more frequently witness the reflected bow, it may be replied, that, if the water is not of greater width than a fraction of a mile, the favorable circumstances already enumerated will very rarely concur to produce the phenomenon with much distinctness; and if there are several miles of water, so as to reflect a beam of large vertical thickness, yet the surface would very rarely be smooth enough, directly after a shower, to form a single and well-defined image of the sun. And it may be added, that there are few persons, except such as have made the theory of the rainbow a matter of careful study, who would consider a bow as particularly noticeable and worthy of description, simply because it happened to intersect the others, especially if, as must ordinarily be the case, the intersecting bow was only a short and indistinct arch.

ART. III.—*On Changes of the Sea-Level effected by existing Physical Causes during stated periods of time;* by ALFRED TYLOR, F.G.S.*

Introduction.

THE First Part of the ensuing paper is occupied with the details of the probable amount of the solid matter annually brought into the ocean by rivers and other agents, in suspension and solution; and the conclusion is arrived at, that the quantity of detritus thus distributed on the sea-bottom would displace enough

* From the Philosophical Magazine for April, 1853.

water to cause an elevation of the ocean-level to the extent of at least 3 inches in 10,000 years.

In the Second Part an endeavor is made to compute the number of such periods of 10,000 years that must have elapsed during the accumulation of the immense mass of recent freshwater strata said to exist in the valley of the Mississippi.

The calculation as to the latter is made from the *data* collected by observers in America, of the extent of the deposit in question; and it is here supposed, first, that in former periods the *same* quantity of mud as at present has been annually carried into the Gulf of Mexico; and secondly, that the amount of sediment deposited on the delta and plains of the Mississippi does not exceed *one-tenth part* of the solid material which has been carried out (suspended in the water of the river) into distant parts of the Gulf of Mexico, or into the Atlantic Ocean itself.

From recent accounts by Mr. C. Ellet, of the United States, it appears that a column of fresh water, 1¼ mile wide and about 7 feet deep, is constantly entering the Gulf of Mexico at a speed of 2 to 2½ miles per hour, and floats on the surface of a stratum of salt water, to which it partially communicates its own velocity. And below this a stratnm of sea-water is found to be flowing in an opposite direction to that of the two strata of fresh and salt water above it. See figs. 1 and 2.

From the data submitted, it would appear that the accumulation of the alluvial deposit of the Mississippi must have occupied a great number of periods, during each of which an elevation of the sea-level of 3 inches may have occurred.

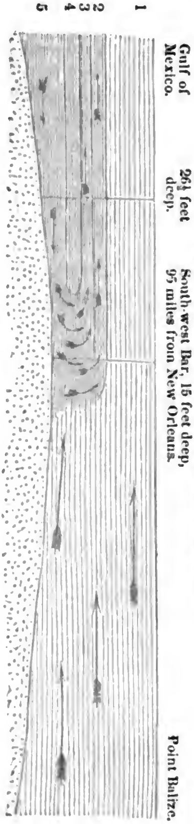
The general conclusion arrived at is, that the sea-level cannot be considered as stationary for practical geological purposes, since the operation of present physical causes would produce a considerable change in its height, even during the construction of a recent deposit like that in the valley of the Mississippi, which may be called small and local compared with those older formations familiar to geological observers.

But the subsidence and elevation of the crust of the earth would be accompanied by alterations of the area of the sea-bed; and the frequency of such movements would therefore furnish additional reasons for not considering the sea-level permanent for the lengthened periods requisite for the accumulation of sedimentary deposits of any magnitude.

In the Third Part of this paper an attempt is made to direct attention to the difficulty of finding any test by which to distinguish strata gradually accumulated during a long-continued upward movement of the sea-level, from those strata formed on a sea-bottom slowly subsiding while the ocean-level was stationary. In either case no change of depth of water may have occurred of sufficient importance to cause the removal of the Mol-

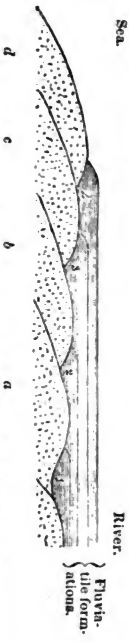
lusca inhabiting the locality, and therefore the discovery of *the same species of organic remains from top to bottom of a thick deposit* is not an absolute proof (as has been supposed*) that

Fig. 1.—*Section of the Bar of the Mississippi.*



1. Stratum of fresh water, 7 feet deep, running per hour from 2 to $2\frac{4}{10}$ miles, and passing over the Bar without losing its velocity.
2. Stratum of salt water, 1 foot deep, running at the same speed as No. 1.
3. Ditto, running at 1 mile per hour.
4. Ditto, supposed to be stationary.
5. Ditto, flowing towards the Bar.

Fig. 2.—*Theoretical Diagram of four successive Bars, with their accompanying fluviatile deposits, showing a section of the junction of a series of Fluviatile and Marine Strata formed during either subsidence of the land or elevation of the sea-level.*



a, b, c, d, 1st, 2nd, 3d, and 4th Bars of marine formation. 1, 2, 3, 4, 1st, 2nd, 3d, and 4th fluviatile deposits.

The marine stratum *a* is contemporaneous with the fluviatile stratum 1; *b* with 2; *c* with 3; and *d* with 4. This holds good whether the land has subsided or the sea-level risen.

* "In formations from a few hundred to a thousand feet and upwards in thickness, the whole of which does actually belong to the same geological age, and is therefore characterized by the same fossils, most curious and important results may be sometimes deduced if the position or relative heights at which the groups of fossils are imbedded be noted; and this is a point usually neglected. For, thanks to the researches of Prof. E. Forbes, the depth of water under which a collection of shells lived can now be approximately told; and thus the movement of the crust of the earth, whilst the strata including the shells were accumulating, can be inferred.

"For instance, if at the bottom of a cliff, say 800 feet in height, a set of shells are buried which must have lived under water only 50 or 100 feet in depth, it is clear that the bottom of the sea must have sunk to have allowed of the deposition of the 700 feet of superincumbent submarine strata; subsequently the whole 800 feet must have been upraised." (Darwin.)

gradual subsidence has occurred during that particular formation; because the condition of equal depth of water during any deposit might be produced either by subsidence of the sea-bottom or elevation of the sea-level, or by both conjointly.

In discussing these questions, the writer has not assumed that during gradual subsidences or gradual elevations, greater denudations or depositions would occur than when the level of the land and sea-bottom was stationary; because it is not certain, either that during such gentle oscillations the forces that would produce denudation are sensibly diminished or increased, or that the rocks which are brought within the reach of denuding forces are necessarily more easily worn away than those which were previously exposed to the same influences.

Part I.

It has long been acknowledged that the quantity of detritus annually carried into the ocean from various sources must displace an equal volume of water, and thus tend to raise the level of the sea. Many years since it was estimated by an Italian that this change might amount to one foot in a thousand years. The general opinion on this subject has been, that the effects produced by the present supplies of detritus would be too minute to be perceptible, and on geological inquiries the ocean-level has been considered as permanent for all practical purposes.* I here propose to offer the evidence of present denudation in certain countries where careful observations have been made, in order to show, that, if such rapid destruction of land occurs in most localities, then the operation of present physical causes must be amply sufficient to effect a perceptible alteration in the sea-level in a moderate space of time.

The mere consideration of the number of cubic feet of detritus annually removed from any tract of land by its rivers, does not produce so striking an impression upon the mind as the statement of how much the *mean surface level* of the district in question would be reduced by such a removal. This information may be obtained by calculation from the published accounts of the quantity of mud annually abstracted from districts of known dimensions by their rivers. In this manner it is found that the Ganges would in about 1751 years, at its present annual rate, carry away from the land it drains (which is supposed to be about 400,000 square miles) as much detritus as would cover that area to the depth of one foot, as the following calculation will show:

Thus, 27,870,400 (superficial feet in a mile) $\times$ 400,000 = 11,151,360,000,000, the number of superficial feet in the area of 400,000 square miles drained by the Ganges. The number

* Manfredi. See Lyell's Principles, edit. 1850, p. 270 and 542.

of cubic feet of detritus discharged annually by that river is 6,368,677,400. (See Lyell's Principles.)

$\frac{6,368,677,400}{11,151,360,000,000} = \frac{1}{1751}$; consequently the reduction of the mean level of the Ganges district is $\frac{1}{1751}$ of a foot annually, or 1 foot in 1751 years.

6,368,677,440 cubic feet of mud discharged $\times$ 856 water to mud $= 5,444,074,288,640 =$ the number of cubic feet of water annually discharged by the Ganges.

$\frac{5,444,074,288,640}{11,151,360,000,000} =$ about $\frac{1}{2}$ a foot, so that the mean annual discharge of water is equal to about 6 inches of rain on the whole area of 400,000 square miles.

The Mississippi, on the other hand, would occupy 9000 years at its present annual rate in reducing to the amount of one foot the mean surface-level of the district it drains, which is computed at eleven hundred thousand square miles. The result is obtained as follows:

If 3,702,758,400 cubic feet of mud are annually carried down by the Mississippi (since the mud is to the water as 1 to 3000), $3,702,758,400 \times 3000 = 11,108,275,200,000 =$ the number of cubic feet of water annually carried by the river into the Gulf of Mexico. The area of district drained by this river is stated at 1,100,000 square miles $- 5280 \times 5280 = 27,878,400 =$ the number of superficial feet in a mile—$27,878,400 \times 1,100,000 = 30,666,240,000,000 =$ the number of superficial feet contained in the area of 1,100,000 square miles drained solely by the Mississippi.

$\frac{11,108,275,200,000}{30,666,240,000,000}$ foot $= \frac{1}{3}$ foot nearly. Consequently the water carried down by the river is equal to about 4 inches of rain over the surface of land drained.

If it be assumed that the levels of the rivers, lakes, and springs are the same in this district at the same period of two consecutive years, the water sufficient to produce the above-mentioned 4 inches of the total of rain-fall upon the whole of this district must have been annually derived from clouds which have been charged with vapor in parts of the earth beyond the confines of the tract of country under consideration; since, if the 4 inches of rain annually carried into the Gulf of Mexico were not replaced from foreign sources, the levels of the rivers, lakes, and springs must rapidly fall.

The estimate of denudation obtained from these countries may be incorrect when applied to other lands differing in altitude and receipt of rain. Besides, many rivers empty themselves into lakes and inland seas, and other extensive tracts are entirely with-

out rain. Since there must be extensive districts which contribute no detritus whatever to rivers, I propose to *assume* that one half the earth's surface only is drained by rivers flowing directly into the sea,* and that the average supply of detritus does not exceed that afforded by the district through which the Mississippi flows (a country where there are no very high mountains, and only a moderate quantity of rain).

The quantity of soluble salts annually carried into the ocean must amount to a very large volume, particularly as river-water always contains matter in solution, while it is only during two or three months of the year that alluvium in suspension is carried down in large quantities. The proportion of soluble salts in the water of the Thames is 17 to 70,000, or 1 to 4117; while the proportion of alluvium suspended in the water of the Mississippi is as 1 to 3000.†

The level of the land is as much reduced by what is carried away in solution, as if this were mud and sand removed in suspension; and a submarine deposit formed from materials brought into the sea in solution will displace a volume of water equal to their former bulk; and therefore, when the annual supply of soluble salts to the ocean does not exceed the quantity separated from solution, the same effect will be produced upon the sea-level by matter introduced, whether it be in solution or suspension. While the proportion of the land to the ocean remains as 1 to 3,‡ it is evident that a reduction of 3 feet in the mean surface-level of the land must take place by denudation before a volume of detritus would be conveyed into the sea sufficient to displace enough water to occasion an elevation of one foot on the ocean-level. (See fig. 3.)

There is great need of further information respecting the amount of sediment carried down by other rivers besides those mentioned; yet if the rate of denudation obtained from the statistics of the Ganges and Mississippi be any guide to what is occurring on the remainder of the globe, we cannot suppose that an *indefinite* time would be required for the performance of a denudation, which should reduce the mean surface-level of the land 3 feet and raise that of the ocean 1 foot. It was during the contemplation of the changes of level that might have been produced by the operations of ordinary physical agents upon the surface of the earth, that Hutton was led to remark that it was not necessary to suppose the area of the land always maintained the

* By reference to Johnston's Physical Atlas, the calculated proportion of land drained by rivers running into European lakes and inland seas may be seen.

† For the statistics of the Mississippi River, see Sir Charles Lyell's Second Visit to the United States, edit. 1847, vol. ii. p. 249 to 253, and other places.

‡ M. Balbi shows (Atlas, Soc. Diff. Useful Knowledge, 1844) that the land on the globe equals 37,647,000 square geographical miles, the sea equals 110,875,000 square geographical miles.

same extent, but that from time to time new land would be formed by the elevatory movements of the sea-bottom to compensate for what had been carried into the ocean by the continued operations of rivers and breakers.* In speaking of the elevation of the sea-level, I only refer to the intervals between those movements of the land which might neutralize in an instant all that had been effected by the operation of rivers for immense periods of time.

It would add very much to the interest of this inquiry if any proof could be brought forward of a recent gradual upward movement of the sea-level. This would, however, be difficult to observe,† on account of the rise in the water concealing the evidence of its former level, except just at the mouths of rivers, where the deposits of fluviatile alluvium might raise the land from time to time and keep it always above the rising waters.

The deposits situated at a few such localities have been described by the best observers, and I hope to show that in several cases there are appearances which might be partly explained by changes of the sea-level, but that a much greater number of cases and more certain evidence would be needed before such an event could be satisfactorily proved. I propose to make some remarks upon this point, after having submitted the evidence which has induced me to believe that the supply of detritus under present

Fig. 3.—*Diagram intended to express the effect upon the sea-level from a waste of* $\frac{1}{9000}$*dth of a foot per annum (a), over all land (from atmospheric and aqueous action), accompanied by a general waste of 186 feet of detritus from each foot of frontage (b) of coast-line (caused by the action of the sea), supposing there is one mile of coast-line to each 100 square miles of land, and to each 300 square miles of water.*

The horizontal dotted line (c') indicates the rise of sea-level equal to $\frac{1}{10,300}$dth of a foot per ann.

* "It is not necessary that the present land should be worn away and wasted exactly in proportion as new land shall appear; or conversely, that an equal proportion of new land should be produced as the old is made to disappear." (Hutton's Theory of the Earth, 1795, vol. i, p. 196.)

† See Darwin, Coral Reefs, &c., edit. 1851, p. 95.

physical conditions is sufficient to raise the ocean level 3 or 4 inches in 10,000 years, provided no subsidence or elevation disturbed the result.

To this subject I now proceed. Sir Charles Lyell's published statements of the quantity of mud annually carried down by the Mississippi and Ganges appear to have been made with so much care, that they may be a better guide to the general rate of removal of soil by rivers than information obtained from a greater number of smaller rivers, which of course are more likely to be influenced by local circumstances. Eleven hundred thousand square miles of land are drained by the Mississippi,* which annually discharges a quantity of water equal in volume to 4 inches of rain, or about one-tenth of the total rain-fall over this entire surface, which forms one-fifth part of North America.† From the mean of a great number of observations, the average quantity of alluvium suspended in the water appears to be 1 part in 3000. Consequently, as the water annually drawn off would cover an area of eleven hundred thousand square miles to the depth of four inches, the quantity of mud removed in the water (as measured at or near the mouth of the river) would cover the same extensive surface to the depth of $\frac{1}{3000}$dth part of four inches, or to the depth of $\frac{1}{9000}$dth part of a foot. Or, in other words, the Mississippi at its present rate would occupy 9000 years in carrying away detritus before the mean surface level of one-fifth part of North America would be reduced one foot.

The Ganges discharges into the Indian Ocean a supply of water equal to about six inches of rain on 400,000 square miles, or a much greater volume of water than the Mississippi pours into the Gulf of Mexico, taking into consideration the difference in size of the countries they drain.

The alluvium suspended in the waters of the Ganges‡ is as 1 to 858 by weight; consequently the detrital matter removed in suspension by the water in one year would cover the land from which it is derived to the depth of $\frac{1}{1751}$ of a foot; that is to say, the Ganges might pour out muddy water at its present rate for 1751 years before the mean level of 400,000 square miles would be reduced one foot in height. The great elevation of the Himalaya range, or possibly a greater rain-fall, may probably occasion the difference between the rates of denudation indicated by the Ganges and the Mississippi. As there are also parts of the earth's surface drained by rivers flowing into lakes and inland seas, and other tracts are entirely without rain, I propose to estimate (as before mentioned) that only half the land contributes detritus in

* See art. Mississippi, Penny Cyclopædia, vol. xxv, p. 277.

† The total rain-fall of the United States is 39 inches between 24½° and 45° N. lat. (Berghaus and Johnston.)

‡ See p. 6.

suspension to rivers flowing directly into the sea.* If this area be annually reduced in level at the same rate as the district through which the Mississippi flows, then the mean level of the land on the globe would be reduced 3 feet in 54,000 years, and consequently the level of the ocean raised 1 foot in the same period by means of the detritus suspended in river-water poured into the ocean.†

But in addition to the sediment carried down by means of rivers, we have also to take into consideration the amount of debris washed into the sea from cliffs during so long a period as that mentioned. It is difficult, however, to form any estimate of what this would annually amount to, for old maps and charts are hardly accurate enough to represent the waste of cliffs by breaker-action even within the last 100 years. Capt. Washington has, however, published a report‡ which gives an account of the encroachment of the sea at intervals on one part of the Suffolk coast. This will give a general idea of the contribution of detritus that may be obtained from some points of a coast-line. The following statements are collected from Capt. Washington's Report on Harwich Harbor in 1844, from which also the figures 4, 5, 6, 7, are copied.

The cliff on the western side of the harbor is about 1 mile long and 40 feet high, and the encroachment of the sea appears to have been at the rate of 1 foot per annum between the years 1709 and 1756, so that the annual supply of detritus was equal to 40 cubic feet for each foot of frontage. Between 1756 and 1804 the advance increased to nearly 2 feet per annum; so that the annual removal of cliff amounted to nearly 80 cubic feet for each foot of frontage.

Between 1804 and 1844 the encroachment of the sea averaged 10 feet per annum, and the annual removal of detritus must have amounted to 400 cubic feet for each foot of frontage. It was during this latter period that extensive dredging for cement stone took place at the base of the cliff.

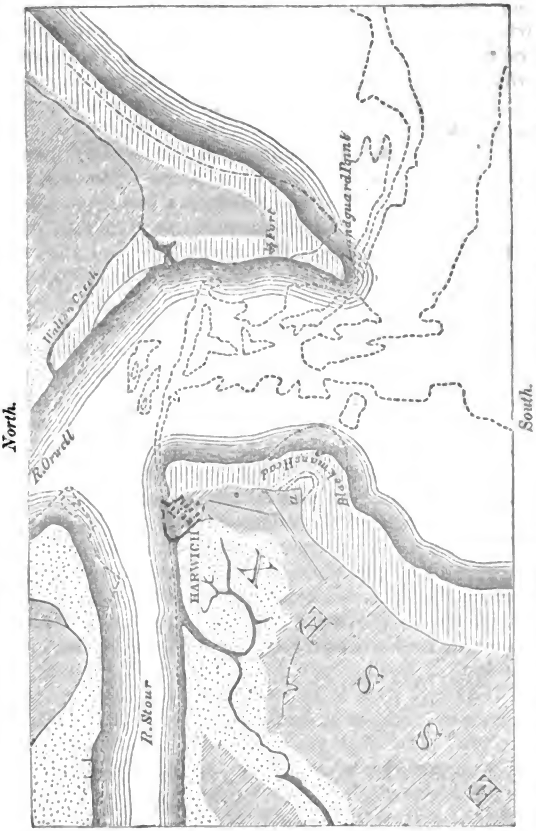
On the eastern side of the harbor events of an opposite character have occurred, for Landguard Point has gained 50 feet per annum in length during the last 30 years. The addition thus made to the land, and to the "littoral zone," presents an interesting example of the rapid accumulation of a local deposit under favorable circumstances. From the appearance of the beach, it would appear that the shingle and sand of which it is formed

* The proportion of land without rain is about $\frac{1}{1200}$dth of the whole. Keith and Johnston say that nearly one-half the drainage-water of Europe and Asia falls into the Black and Caspian Seas. The proportion for Africa and America is not known.

† It is not improbable that the *solvent* powers of rain and river-water are as important agents in the removal of land as the agency above mentioned. Definite calculations on this subject remain to be made.

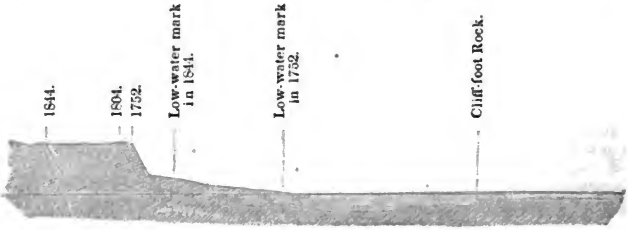
‡ Tidal Harbors' Commission, First Report of 1845.

Fig. 4.—*Map of Harwich.*



a. Beacon Cliff, with dotted lines indicating the changes that have taken place in high and low-water mark. The dotted line shows the former outline of Languard Point.

Fig. 5—*Section showing the Destruction of Beacon Cliff between* 1752, 1804, *and* 1844.

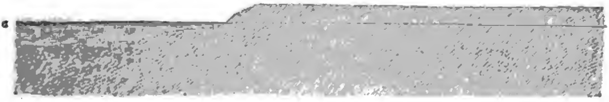


have been brought from the north, in which direction there are recorded instances of great destruction of land by storms during the last 300 years. The aspect, however, of much of the coast-line appears as if it had remained unaltered for a very long period, except in the manner Mr. R. A. C. Austen* alludes to when he remarks, "that although the sea for months together, and in places even for whole years, may not acquire any fresh spoil, yet there are few hours when its waters are unemployed in fashioning and abraiding the materials already acquired." In considering the effect upon the sea-level caused by sand, mud, and pebbles washed in by the breakers, it is only necessary to regard those materials that may be brought in from cliffs above high-water mark; for the movement of sand and mud below high-water mark can produce no effect upon the sea-level, because the abstraction of these materials from one part of the shore is exactly balanced by their addition to some other part. For instance, some of the flint-pebbles which have contributed to the recent deposit at Landguard Point have been brought along shore a great distance from their original position on the cliff. These flints formed an addition to the sea-bed, and tended to raise its general level by displacing an amount of water equal to their bulk the moment they fell on the shore below high-water mark; and it is quite clear their subsequent movements, either beneath the wave or on the beach, could produce no further effect upon the sea-level, the spaces they occupied on one part of the coast being balanced by the vacancy left at some other. It is also evident that the beach at Languard Point will go on extending so long as the fresh supplies of shingle and sand from the north exceed the removals southward.

Figs. 6, 7.—*Sections showing the Increase of Landguard Point between* 1804 *and* 1844

Beach end in 1804.

Beach end in 1844.



a. a. Low-water level of ordinary springs.

In the same manner the continued supplies of pebbles from the westward enables the Chesil Bank to preserve its position. As

* Austen, Quart. Jour. Geol. Soc. vol. vi. p. 71–73; and De la Beche, Geol. Observer, 1851, p. 65.

soon, however, as any disturbing causes interrupt the supplies of new material, the sand and shingle beaches dependent upon them must soon disappear; and in fact the termination of every beach will be at that point where the waste and abrasion by breaker-action are balanced by the supply of pebbles and sand drifted from other places. Although it appears clear that only the detritus obtained from cliffs above high-water mark need be taken into calculation, yet I regret to find that scarcely any data of this kind exist, and therefore it is not possible to ascertain the probable effect upon the sea-level that is being produced by the detritus so derived. In the same manner the per-centage of soluble salts in the water of the few large rivers of which notes have been published has not been given separately from the per-centage of matter in suspension, and therefore we are in ignorance of the supplies that are annually introduced into the ocean from the formation of submarine deposits from materials dissolved in the sea-water. When the rise in the sea-level from the effect of alluvium brought in suspension by rivers was being considered, I supposed that that cause alone might produce an elevation of one foot in 54,000 years; but in order to make some allowance for the similar effects that must be produced by the introduction into the ocean of materials from above high-water mark on coast-lines* by breaker-action, and also by the formation of submarine deposits from materials which were brought into the ocean in solution, I now propose to consider that all these causes together might produce an elevation of the sea-level equal to one foot in 40,000 years, or three inches in 10,000 years.

Mr. Darwin has remarked, that "the knowledge of any result, which, with sufficient time allowed, can be produced by causes, though appearing infinitely improbable, is valuable to the geologist, for he by his creed deals with centuries and thousands of years as others do with minutes." For these reasons, even if, upon further investigation, it should be found that the true rise in the sea-level is much less than three inches in 10,000 years (in periods undisturbed by subsidences and elevation), yet it may still be an important element in accounting for those changes which we are now about to consider.

(To be continued.)

* The rough estimation of the extent of coast-line, kindly supplied by Mr. A. K. Johnston, (Nov. 1852), is as follows:—

	Nautical miles (60 to a degree.)	English statute miles ($69\frac{1}{2}$ to a degree.)
Europe, - - -	17,200	20,425
Asia, - - - -	30,800	34,825
Africa, - - -	14,000	16,625
America, - - -	37,600	44,656
	99,600	116,531

Art. IV.—*On the Phosphate of Iron and Manganese from Norwich, Mass;* by Dr. J. W. Mallet.

This mineral, first observed by Dr. E. Hitchcock, Jr., and Mr. Hartwell, and since described by Professor Dana and analyzed by Mr. Craw,* possesses much interest from the distinctness of its crystals (which yet in their angles present unaccountable irregularity), since it belongs to a class of minerals which are in general found massive, or but imperfectly crystallized. The following are the results of a chemical examination of some pure specimens, for which I am indebted to Mr. C. Hitchcock. They do not add much to our knowledge of the mineral, but serve to confirm essentially the former determinations by Mr. Craw.

The crystals are opaque and of a dark brownish black color, and give a beautiful violet streak. Sp. gr. = 3·364, higher therefore than that of the specimen analyzed by Mr. Craw, which he gives as 2·876. Hardness about 5. Before the blowpipe the reactions of phosphoric acid, iron, and manganese, are easily obtained.

A portion of the mineral was pulverized, weighed, and kept for some time at the temperature 100° C. The loss of weight was scarcely appreciable. This portion was then exposed to a bright red heat, and on cooling was found to have assumed a light brownish yellow color, and to have lost 6·33 p. c. In another experiment the loss was 5·97 p. c. To ascertain the amount of water contained in the mineral, a portion, dried as before at 100° C., was heated in a glass tube in a stream of dried air, and the water expelled was absorbed by chlorid of calcium and weighed. It amounted to 1·92 p. c. In another experiment the pulverized mineral was heated in dry hydrogen, and lost 2·18 p. c. of water beyond that formed by the reduction of the peroxyds of iron and manganese to protoxyds.

The phosphoric acid and peroxyds were determined by fusion with carbonate of soda, and the lime, magnesia, and lithia, were estimated in a separate portion. The results of analysis were—

	1.	2.	3.	4.
Phosphoric acid, - -	43·12	43·35	42·65	——
Peroxyd of iron, - -	29·90	29·23	29·37	——
Sesquioxyd of manganese,	23·02	21·98	22·76	——
Lime, - - -	——	——	——	·09
Magnesia, - - -	——	——	——	·73
Lithia, - - -	——	——	——	1·79

* Amer. Jour. of Science, [2] xi, 99, 100.

The iron and manganese appeared to exist altogether as sesquioxyds. The lithia contained a little soda, but the quantity of the latter was too small to separate and weigh.

The mean of these results makes the composition of the mineral—

		Atoms.	
Phosphoric acid, - - - -	43·04	·598	
Peroxyd of iron, - - - -	29·50	·369	·654
Sesquioxyd of manganese, -	22·59	·285	
Lime - - - - - -	·09	·003	
Magnesia, - - - - -	·73	·036	·163
Lithia, - - - - - -	1·79	·124	
Water, - - - - - -	2·05	·228	
	99·79		

Hence we have the complex and not very probable formula $5R_4\dot{P}_3+R_5\dot{P}_3+7\dot{H}$; but if we consider, as suggested by Mr. Craw, that the iron and manganese originally existed as protoxyds, the above numbers give the equivalents of phosphoric acid, protoxyds, (adding in the lithia and earths), and water, in the ratio 598 : 1471 : 228, or very nearly 2 : 5 : 1, although the water does not amount to quite 1 atom. Hence we have the much simpler formula, $\dot{R}_5\dot{P}_2+\dot{H}$, which is that of Damour's alluaudite, if we reduce the per- to protoxyds as above, though that mineral differs from the present in containing soda instead of lithia, and in the manganese actually existing to a great extent as protoxyd, while in the substance from Norwich the peroxydation of the metals has been completed.

There have been already described three phosphates occurring in nature which have this general formula, with the exception of the water, which varies in amount in each—1st, this mineral from Norwich and the Alluaudite from Limoges, the formula of which is $\dot{R}_5\dot{P}_2+\dot{H}$; 2nd, Heterosite or Hetepozite, of Dufrénoy, from Limoges, with the formula $\dot{R}_5\dot{P}_2+2\dot{H}$; and 3rd, Hureaulite, also from Limoges, and represented by $\dot{R}_5\dot{P}_2+8\dot{H}$. Whether any of these minerals deserve to rank as distinct species seems very doubtful. It would seem more likely that they are all the mere products of a gradual alteration, in the course of which the heavy metals were more or less peroxydized, water was taken up, and probably some of the alkaline constituents of the mineral were lost.

This last mentioned action seems indicated as having affected the lithia of the phosphate from Norwich, since the phosphoric acid found is a little in excess of that required by the formula.

ART. V.—*On the Homœomorphism of Mineral Species of the Trimetric System;* by JAMES D. DANA.*

ALTHOUGH many cases of homœomorphism among minerals of the Trimetric System have been pointed out by different investigators, no general review of the species has yet been made. We propose, therefore, to consider the relations in form among all the species, believing that in this way, and in this way alone, we may arrive at the true system among the homologies, and the principles upon which they rest.

In the outset, it is important to ascertain what may be considered true criterions of homology in the comparison of forms. In a trimetric crystal there are often several occurring prisms in the three axial directions, the vertical, macrodiagonal, and brachydiagonal, and as either axis might be assumed to be the vertical axis, and either prism in each direction the fundamental prism,† there are wide limits as to the possible cases of homœomorphism that might be made out. So among rhombohedral forms, in Calcite for example, rhombohedrons occur of a great variety of angles, and homœomorphism may be deduced between it and almost any rhombohedral species, provided any one of these rhombohedrons may for the time be taken as fundamental.

There is obviously one right position for the comparison of two species, and the others are wrong. Hence it is essential to have some basis for deciding upon this point, and especially for ascertaining which is the true vertical axis, in order that we may compare like axes and their planes with one another.

It must be admitted that there are no tests of homology which are of invariable application. As elsewhere in science, the relations of species are to be ascertained rather by the general range of characters, than by the severe application of one single law. But there are important aids, and their exact value should be understood.

1. *Cleavage.*—Cleavage is one of the most important means. In the trimetric system, it may take place parallel, (1) to the axial sections, one or all; (2) to the lateral planes of different rhombic prisms; (3) to octahedral planes.

a. When cleavage is parallel to one or more rhombic prisms, it is generally true that, (1) the vertical axis of the prism of most perfect cleavage is the proper vertical axis of the species, and also that (2) these cleavage prisms for different species are homologous prisms.

* From the Annals of the Lyceum of Nat. Hist. New York, vi, 37, March, 1854.

† A fundamental vertical prism is one which has for its axes *b*, *c*, the ratio 1*b* : 1*c*. The fundamental macrodome and brachydome have the analogous ratios 1*a* : 1*b*, and 1*a* : 1*c*. These are the *unit* prisms.

Hornblende and Augite correspond to the *first* of the two principles just stated, but are well known exceptions to the *second:* the cleavage prism of one has twice the breadth of that of the other. These species, nevertheless, are closely homœomorphous, and hence there may still be homology when the cleavage forms have a simple axial relation, as 1 : 2. Diaspore and Göthite exemplify the same fact; the former has an imperfect cleavage parallel to the prism $i\bar{2}(\infty P\bar{2})$. Staurotide and Andalusite may be viewed as another example. The occurring forms of these species have the same relation as those of hornblende and augite, or a ratio of 1 : 2, in the longer lateral axis, and traces of cleavage correspond; while in topaz, a third homœomorphous species, both forms are common, and indistinct cleavages are described as occurring parallel to each.

In some cases, when there are two cleavage prisms at right angles with one another, we are required by the analogies of the species to take as the vertical axis that parallel to the prism of least perfect cleavage; but such examples are rare.

b. It is common to find a prismatic and a diagonal cleavage existing together. In a single natural group of species, the former may become obsolete, while the latter is highly developed, or the reverse; and therefore *the presence or absence of a diagonal or basal cleavage is no test of identity.* The anhydrous sulphates are a prominent example. In *Celestine* and *Heavy Spar* a basal and prismatic cleavage exist, and the two diagonal cleavages are imperfect; while in *Anhydrite*, of the same group, the basal and diagonal are highly perfect, and no prismatic cleavage has been detected. In rhombohedral forms, a basal cleavage often occurs along with a rhombohedral, and in species actually homœomorphous, it may become the only cleavage, or be wholly obsolete. It is, however, often true, that a particular direction of cleavage characterizes a group of species. In the *Heulandite* group there is a perfect clinodiagonal cleavage; the *Feldspars* have a basal and clinodiagonal; the species of the *Calcite* series have a perfect rhombohedral cleavage, and no distinct basal, while the *Corundum* series have generally a basal cleavage, more distinct than the rhombohedral.

2. *Twin-composition.*—In compound crystals composition takes place in general, parallel to planes or sections of fundamental value. This is well seen in monometric forms, in which the only planes of composition are, (1) the faces of the cube; (2) the faces of the regular octahedron, or planes truncating the solid angles; (3) the faces of the dodecahedron, or planes truncating the edges of a cube. It will be observed that the composition is either at the extremities of the axes (1), or at points exactly intermediate between *three* axes (2), or between every *two* (3). This narrow limit to the possible directions of

twin-composition gives importance to its indications, and therefore ***similarity in modes of composition suggests identical or homologous relations between the planes of composition in different species, and vice versa.*** Thus when we observe different species, as *Aragonite*, *Cerusite*, etc., affording stellate twins and hexagonal forms by composition parallel to the faces of a prism nearly 120° in angle, we infer that the prisms are homologous; and when similar prisms occur in *Chrysoberyl* or *Copper Glance*, we conclude that the prism of 119° in these species, parallel to faces of which the composition takes place, is the true vertical prism, as in Aragonite. The fact that $120° \times 3$ or $60° \times 6$ equals 360°, is evidently the fundamental reason for the occurrence of such twins; and hence in other species a like angle for the vertical prism, especially if the prisms are alike in their other dimensions, would be likely to produce the same result.

Hence we conclude that the sulphates (RO, SO^3), although affording in one direction a prism near 120° in angle, have not this prism as the fundamental vertical prism, for stellate composition, does not occur parallel to it; the true vertical prism is the one usually so assumed—that of 101° to 104°.

Bournonite affords another illustration of this subject. G. Rose has assumed its homœomorphism with Aragonite, on the ground that it has a vertical prism of 115° 58′. But this species, instead of forming twins parallel to the faces of this prism, actually affords cruciform twins parallel to a prism of 93° 40′, the one usually taken as the fundamental prism. The prism of 115° 58′ is $i\,\frac{3}{2}\,(\infty P\,\frac{3}{2})$ and there is no reason for regarding it as other than a secondary prism.

Chrysoberyl has been placed near chrysolite by the author, and also by M. Scacchi, of Naples. In a certain position the resemblance in angle exists. But still the species are rather widely remote, inasmuch as the twins, like those of Aragonite, parallel to faces of the prism of 119° 46′, show that this is the fundamental prism. Chrysolite affords no such twins; the angle of its vertical prism is 94° 3′, and it belongs to a different zone. Chrysoberyl is actually near Aragonite in angle; it has a brachydome of 108° 26′, and Aragonite one of 109° 39′.

Monoclinic prisms near 120° in angle, never present stellate twins like trimetric prisms. Such twins in oblique forms appear to be impossible, since they require a regular symmetrical character in the molecule above and below the middle section. This remark appears to apply also to hemihedral forms of the trimetric system, like those of datholite.

3. *General Habit of Crystals.*—A resemblance in general habit is often to be detected between species related in crystallization. Thus Brookite, as figured in this Journal, vol. xvii, p. 86, resembles Columbite in the general arrangement of its planes; and we

cannot mistake, in comparing them, as to the homologous prisms of the two. Again, it requires but a glance at the forms of feldspar and pyroxene to see that the habit here is wholly opposed to any homœomorphism between the species, while the family resemblance among the feldspars themselves is very striking.

4. *Frequency of Occurrence of Planes, or Zones of Planes.*—This criterion is sometimes of importance, and still it is very likely to lead astray. It is the common principle on which crystals are mathematically described, for that is usually assumed as the fundamental form which will give the simplest mathematical view of the crystallization. But it is well known that in many species *secondary* forms are most common. In Quartz, the fundamental form is rarely seen; in Calcite, the rhombohedron $-\frac{1}{2}R$ and scalenohedron R^3, are of far more frequent occurrence than R; in fluor, cubes are more common than octahedrons, the cleavage form; and octahedrons, when they occur, often have their surfaces made up of the angles of minute cubes; and the same is true of many species. It is consequently no certain evidence, when a prism terminates in a pyramidal summit (as in mesotype), that it is the unit pyramid, or even that the occurring prism in a species is one of the three unit prisms. It is natural to assume that an occurring zone of planes is one having the simplest ratios, and that among them exists one having the axial ratio of unity, $1a:1b:1c$. But this may be far otherwise. Anhydrite is a familiar example. The occurring prisms, according to the view of the author,* are $\frac{2}{3}\bar{i}(\frac{2}{3}P\bar{\infty})$ and $\frac{3}{4}\breve{i}(\frac{3}{4}P\breve{\infty})$, which bring out well the homœomorphism of the species with the other allied sulphates; but the three octahedral planes are then $\frac{3}{4}\breve{\frac{9}{8}}$, $\frac{6}{4}\breve{\frac{12}{8}}$, and $\frac{9}{4}\breve{\frac{27}{8}}$; and in any other view that recognizes the homœomorphism, the expressions for the planes are scarcely less complex.

We cannot be too guarded, therefore, when deducing the form for comparison with another species, in relying on the prevalence of certain planes. Valuable hints are often thus given, but they may lead to error.

The lustre or smoothness of planes is a better guide, though far from certain. The fundamental vertical prism in Barytes is generally less highly polished than many other faces; and as we have above remarked, the octahedrons of fluor have often rough surfaces.

The prevailing direction of the more extended zones of planes, especially the octahedral, often suggests rightly which is properly the terminal plane of the prism, these zones rising towards that plane; and they thereby afford a hint as to which is the vertical axis. In dimetric and hexagonal species, this criterion is a sure

* Am. Jour. Sci., [2] 17, 88.

guide (except sometimes in hemihedral forms); but here it is not needed, as the basal plane is fixed from the nature of the prism. The principle holds true for topaz and many trimetric species. In the rhombic octahedron of sulphur, in which either axis might be made the vertical, the *apical* angles, in which the true vertical axis terminates, are at once distinguished in modified crystals, by the cluster of planes about them. But the ambiguous cases are numerous, and this criterion, like others, is not an unfailing reliance.

When we may succeed in fixing upon the vertical axis in a species, and also the unit vertical prism, it is often difficult to determine which planes about the base should be taken as the unit domes or octahedron; and often there is a choice between two or three planes equal in lustre and size; and consequently it may be altogether doubtful whether the vertical axis equals $1a$, $\frac{1}{2}a$, or $\frac{2}{3}a$. Crystallographers may take whichever is most convenient without any important objection. But when looking to homœomorphous comparisons, it is important that the special claims of each should be duly considered, instead of blindly adopting those which authors have found best to serve them in their mathematics.

5. *Analogies derived from Relations in Composition and Form.*—Similarity in chemical composition has long been known to suggest similarity in crystallization; and among species thus related it is usually safe to assume that prisms approximate in angle are homologous. Other more indirect analogies are often of weight, as illustrated in the case of Leadhillite, in a paper by the writer, on page 210, vol. xvii, of this Journal. We there see that the sulphates and sulphato-carbonates are parallel throughout in their homœomorphisms, and we ascertain with much probability which is the fundamental vertical prism in Leadhillite.

6. *Values and Relations of the Angles of Forms.*—In the series of prisms in each axial direction, the vertical, macrodiagonal, and brachydiagonal, the planes, as is well known, have simple axial ratios, and the more common ratios are 1 : 1, 1 : 2, 2 : 3. If but a single prism occur in either direction, it is easy to calculate the values of the angles of other prisms having the above mentioned relations. This gives a series of angles. If, then, two species correspond nearly with one another in one element of such a series, they are also related in others, and they are evidently related in form. From the exceptions to the several criterions mentioned, it is evident that the absolute relation of the axes may not in many cases be ascertainable. The vertical axis, for example, may be doubled in length without violating any principle that can be laid down; or it may be halved in the same way. But we may with certainty determine whether forms are

related in the *series* of angles, and when so related, the species are in a correct sense homœomorphous. Augite and Hornblende may be regarded as differing in this way, as we can by no criterion decide that the lateral molecular axes of Hornblende and Augite are identical; we know that they are so related that one form might be a secondary to the other,—that the prism of hornblende has its orthodiagonal twice that of augite in length, and that the serial relation of the forms is such that they may be said to belong to one type. This point will be abundantly illustrated beyond. We observe that in all the comparisons made in the following tables, the only changes from the forms assumed by authors made on the above principles to exhibit the homœmorphism of species, are such as depend on the simple ratios, 1 : 2, 2 : 3, 3 : 2, 2 : 1. No torturing of the forms has been required by employing unusual or complex ratios, notwithstanding the hypothetical manner in which the received fundamental forms have been in many cases assumed.

The preceding are some of the methods that are of importance in determining the crystallographic homologies of species. It appears that the *first* point to be determined, is the true vertical axis of species under comparison; and this being ascertained, the *second* is to fix upon the fundamental or unit vertical prism, or that which shall give the relative values of the lateral axes; and *third*, we have to determine upon a unit dome, either a macrodome or brachydome, in a trimetric species, or else the unit octahedron, in order thereby to ascertain the true value of the vertical axis; and *fourth*, to make out the serial relations of forms, for a full comparison where the actual relations of the axes may be doubtful.

While studying forms by the above methods, it is also of interest to compare them as a whole without reference to which is the vertical prism; and only by viewing them thus in every different light can we fully understand their actual dimensional relations. In this point of view, the results of Hausmann respecting the anhydrous sulphates and carbonates are highly interesting, although secondary in importance to comparisons between the forms when placed in homologous positions.

The position of the vertical axis derives special importance from the crystallogenic nature of molecules. In a trimetric molecule, if we suppose three crystallogenic axes, a vertical and two lateral, while the vertical is at right angles to the lateral, from the nature of the form, the lateral may either intersect at right angles, corresponding to the form of a rectangular prism, or at oblique angles, corresponding to the angle of a rhombic prism; that is, in other words, they may connect the centres of the lateral faces of a rectangular prism or of a rhombic prism. Either condition will express the forces as indicated by the form, and result in the

solids of the trimetric system. And when the cleavage prism is rhombic, there is better reason for regarding the lateral axes as oblique in their intersections, than rectangular. The subject of twin crystals affords evidence that this is not mere hypothesis;* and additional proof is shown beyond in the relations of the domes to the angles of the regular octahedron. And still another argument may be derived from the relations of the domes in angle to the vertical prism. If such views may be adopted, it must obviously be essential to correct comparisons of form between species, that the *vertical* axis should be determined on the best possible data.

The preceding remarks are offered as introductory to the following tables of the values of the axes and principal prisms in trimetric mineral species. I have endeavored to apply with fidelity the principles that have been briefly reviewed. The unit prisms, as has been stated, are not in all instances those assumed as such by other authors; but although they are in general well entitled to be so regarded, they are not all supposed to be the unit prisms, as has been explained by referring to Hornblende and Augite as examples. An exhibition of the mathematical relations of the forms is the main point in view. Whenever we have placed in the columns of unit prisms, angles usually regarded as those of other prisms, it is stated by a mention of the form to which they have been commonly referred. Thus, under Chrysolite, the prism taken as $1\bar{\imath}$ is $\frac{1}{2}\bar{\imath}$ of most writers, as mentioned. These forms, as observed, differ from the unit prisms, either by the ratio 1 : 2 or 2 : 3, ratios of the simplest kind.

The trimetric species are naturally divided into *four* grand groups, differing in the angle of the fundamental or unit vertical prism (angle $I : I$ of the tables, $\infty P : \infty P$ of Naumann), as follows:—

1. Angle $I : I$ from $90\frac{1}{2}°$ to 95°.
2. Angle $I : I$ near 102°, or from 98° to 105°.
3. Angle $I : I$ near 110°.
4. Angle $I : I$ near 120°.

It will be shown that these specific values of the angle $I : I$ are dependent on a principle of the most fundamental character. The *third* Group may however belong with the *second* as remarked upon beyond.

The angles mentioned in the table are the obtuse angle of the prism $I : I$ (column 1), and the summit angle of the unit macrodome and brachydome ($1\bar{\imath}$ and $1\breve{\imath}$ or $P\bar{\infty}$ and $P\breve{\infty}$).†

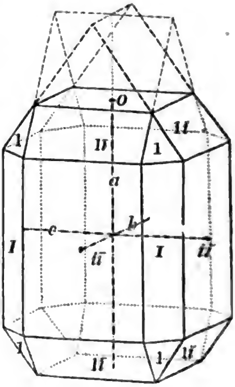
* See the author's Treatise on Mineralogy.

† To avoid any ambiguity in the angles referred to in the following pages, and render the subject intelligible to those who may not be familiar with crystallographic language, a few explanations are here given. The annexed figure represents

TABLE I.

Angle of Vertical Prism near 90°.

	Vertical Prism. $I : I$	Macrodome. $1\bar{\imath} : 1\bar{\imath}$	Brachydome. $1\breve{\imath} : 1\breve{\imath}$	Axes. $a : b : c$
I.				
Thomsonite, - - - - -	90° 40′	108° 18′	108° 56′	0·72253 : 1 : 1·0117
Mesotype, - - - - -	91°	($2\bar{\imath}$)108° 46′	($2\breve{\imath}$)109° 42′	0·71644 : 1 : 1·0176
Harmotome, - - - - -	91° 46′	108° 48′	110° 26′	0·71626 : 1 : 1·0312
Wöhlerite, - - - - -	90° 54′	108° 2′	108° 56′	0·7261 : 1 : 1·01583
Pyrolusite, - - - - -	93° 40′	104° 22′	($\frac{1}{2}\breve{\imath}$)107° 54′	0·77601 : 1 : 1·0661
Andalusite, - - - - -	90° 44′	109° 6′	109° 50′	0·71198 : 1 : 1·0129
Lievrite, - - - - - -	($\frac{2}{3}$)91° 32′	111° 14′	112° 40′	0·68429 : 1 : 1·0271
Staurotide, - - - - -	($\frac{1}{2}$)93° 8′	($\frac{1}{2}\bar{\imath}$)108° 12′	111° 10′	0·72388 : 1 : 1·05617
Wavellite, - - - - -	($\frac{1}{2}$)90° 34′	($2\bar{\imath}$)106° 14′	106° 46′	0·75047 : 1 : 1·0099
Olivenite, - - - - } Libethenite, - - - }	92° 30′	108° 28′	110° 50′	0·72034 : 1 : 1·0446
Caledonite, - - - - -	95°	($\frac{1}{2}\bar{\imath}$)105° 8′	($\frac{1}{2}\breve{\imath}$)109° 54′	0·76568 : 1 : 1·0913
Chondrodite, - - - - -	94° 26′	($\frac{1}{2}\bar{\imath}$)106° 52′	($\frac{1}{2}\breve{\imath}$)111° 4′	0·74176 : 1 : 1·0805
Antimony Glance, - -	90° 45′	($\frac{2}{3}\bar{\imath}$)109° 26′	($\frac{2}{3}\breve{\imath}$)110° 8′	0·6901 : 1 : 1·0132
Do. do. - -	90° 45′	($1\bar{\imath}$) 88°	($1\breve{\imath}$) 88° 47′	1·0352 : 1 : 1·0132
Polycrase, - - - - -	95°	($1\bar{\imath}$) 88° 30′	($1\breve{\imath}$) 93° 58′	1·02655 : 1 : 1·0913
II.				
Epsomite, - - - - -	90° 34′	120° 4′	120° 38′	0·57657 : 1 : 1·01
Diaspore, - - - - -	93° 52′	115° 16′	118° 42′	0·63398 : 1 : 1·0699
Göthite, - - - - -	94° 52′	113° 6′	117° 30′	0·66063 : 1 : 1·0888
Polianite, - - - - -	92° 52′	115° 26′	118°	0·6317 : 1 : 1·0513
Euchroite, - - - - -	92° 8′	117° 20′	119° 13′	0·6088 : 1 : 1·038
Topaz, - - - - - -	($\frac{1}{2}$)93° 8′	($\frac{3}{8}\bar{\imath}$)115° 22′	($\frac{1}{2}\breve{\imath}$)118° 10′	0·63258 : 1 : 1·05617
Chrysolite, - - - - -	94° 3′	($\frac{1}{2}\bar{\imath}$)115° 36′	($\frac{1}{2}\breve{\imath}$)119° 12′	0·6297 : 1 : 1·0733
Triphyline, - - - - -	94°	($\frac{1}{2}\bar{\imath}$)118° 27′	($\frac{1}{2}\breve{\imath}$)121° 55′	0·59549 : 1 : 1·0724
Bournonite, - - - - -	93° 40′	($\frac{2}{3}\bar{\imath}$)115°	($\frac{2}{3}\breve{\imath}$)118° 14′	0·63745 : 1 : 1·0662
Do. - - - - -	"	($1\bar{\imath}$) 92° 34′	($1\breve{\imath}$) 96° 12′	0·95618 : 1 : 1·0662
? Warwickite, - - - -	93°–94°			
? Lanthanite, - - - -	93° 45′			



a rectangular prism with replaced edges and angles, and the three axes a, b, c. O is the basal plane of the prism; $\bar{\imath}\bar{\imath}$ the larger lateral plane, parallel to the *longer* lateral axis, or macrodiagonal, c; $\breve{\imath}\breve{\imath}$ the smaller lateral plane parallel to the *shorter* lateral axis, or brachydiagonal, b. I are planes on the vertical edges of the rectangular prism, which when extended so as to meet one another, would form a vertical rhombic prism, having its axes b, c, in the ratio of $1b : 1c$. It is therefore the *unit* or *fundamental* vertical prism. $1\bar{\imath}$ are planes parallel to the longer lateral axis, c, having for the axes a, b, the ratio $1a : 1b$; extended upward they form a *dome*, called the *macrodome*. The planes $1\breve{\imath}$, in a similar manner, constitute a *brachydome*, or dome parallel to the *shorter* lateral axis, and having the ratio $1a : 1c$. These two domes are therefore the *unit* domes. The planes 1 on the eight angles are planes of an octahedron, having for the axes a, b, c, the ratio $1a : 1b : 1c$; it is therefore the *unit* octahedron.

Taking axis $b = 1$, $c =$ tangent of half the angle $I : I$; and $a =$ cotangent of half the summit angle $1\breve{\imath} : 1\breve{\imath}$. These two angles alone are a correct exhibition of the degree of homœomorphism between species; all other angles are dependent upon these, and there-

The preceding table is naturally subdivided into two sections:

I. Species having the summit angles of the domes, near 109°.
II. Species having the summit angles of the domes, near 120°.

In the first of these groups there is a remarkable closeness of coincidence to the angle mentioned; and in the second, the variation from 120° in the brachydome is but small. The vertical axis typical of the groups differs therefore theoretically as $\sqrt{3} : \sqrt{2}$, which is nearly as 6 to 5.

In section I, the axes *a*, *b*, *c*, have nearly or typically the ratio $1 : \sqrt{2} : \sqrt{2}$. In Andalusite, the ratio is almost identical with this, and 109° 28′ is exactly a mean between 109° 6′ and 109° 50′, the angles given for the two domes.

In section II the ratio of the axes approaches $1 : \sqrt{3} : \sqrt{3}$, which it is very closely in Epsomite, the domes of which are nearly 120°.

109° is approximately the angle of the regular octahedron, the faces of which solid incline to one another 109° 28′. Moreover the angle of the vertical prism *I* váries but little from that of a cube, or 90°. Here is an obvious relation to monometric forms not to be overlooked. Moreover, the angle 120°, in section II, is the angle of the dodecahedron.

In the change, therefore, in a case of dimorphism, from the monometric to these trimetic forms, the characteristics of the monometric molecule, or form, are to a considerable degree retained.

It is to be observed that the domes $2\bar{\imath}$ and $2\breve{\imath}$ for the same species afford nearly the angle 71°, the supplement of 109°; in fact, 109° 28′ for $1\bar{\imath}$ would give precisely the supplement 70° 32′ for the summit angle of $2\bar{\imath}$. In several of the species the occurring dome is that of 70°–71°, instead of that of 109°; so that either might be taken as characteristic of the first section in table I. 70° 32′ is the summit angle of the regular octahedron.

If, therefore, we compare the regular octahedron with the *rectangular* octahedron that would result from the united domes $2\bar{\imath}$ and $2\breve{\imath}$ in the species of section I, we find them nearly identical. We observe, further, the important fact, that *the axes of the regular octahedron correspond to diagonals between the apices of the basal angles of the rectangular octahedron.* But these axes in the latter solid, cross at *oblique angles* equal to the angle of the rhombic prism *I*, instead of at right angles; and they correspond to lines between the centres of opposite lateral faces of the rhombic

fore a long series, for the sake of comparison although often given, is not necessary or even desirable.

As $1\bar{\imath}$ is the unit macrodome, so $2\bar{\imath}$ will be a macrodome with the vertical axis *twice* as long; $\frac{2}{3}\bar{\imath}$, one *two-thirds* as long; $\frac{1}{2}\bar{\imath}$, one *half* as long; and so on. The first figure or letter in a symbol refers always to the vertical axis *a*, and the other to the *longer* or *shorter* lateral axis, according as it has over it the long or short mark, ¯ or ˘.

prism, I, and not to those between the centres of its opposite lateral edges. In other words, these lines are not the *crystallographic* axes of the Trimetric system, but what the author has called the *crystallogenic* axes. This is one reason alluded to on a preceding page for believing that the crystallogenic axes are not necessarily the same lines with the crystallographic. The latter are lines assumed for the convenience of calculation.

If instead of the domes $1i$ in section I, the species had afforded $\frac{2}{3}i$ as common and dominant forms, and these were taken as the unit domes, then the unit octahedron, in place of the domes, would have the pyramidal angles near 109°, approaching those of the regular octahedron. Could we therefore assume this as the fundamental octahedron for the species, the derivation of the octahedron from the regular octahedron would be a change in the lengths only of the axes, and not in their angles of intersection. But this assumption would do violence to the facts. Still in Antimony Glance, we have an example probably of this form and mode of derivation; the dominant form is an octahedron, with the pyramidal angles 109° 16′ and 108° 10′, and basal 110° 58′. Bournonite and Polycrase may be other examples of a similar nature, though diverging more in their angles.

Although the two sections are strongly marked in the above table, still the species of one may be regarded as homœomorphous with those of the other. Thus Chrysolite of Group II, and Chondrodite of Group I, have been recognised by Scacchi as homœomorphous. So also Andalusite and Topaz are essentially homœomorphous, as well as similar in chemical formulas. In both of these cases, one of the species contains fluorine, and this is evidently the occasion of the wide divergence. Yet in one instance the fluorine species (chondrodite) belongs to section I, and in the other (topaz) to section II.*

The table affords examples, also, of the principle stated on a preceding page, that homœomorphous species, while identical in the particular axis which is the vertical, may vary by a simple ratio (1 : 2 or 2 : 3) in the axes, and that they are to be recognised as species that belong to a specific system of ratios, rather than to definite and identical dimensions.

Andalusite, Staurotide, and Topaz, have this relation. The forms of these species may be referred to a similar type; yet we cannot affirm that the axes have the near identity presented in the table, rather than a multiple ratio of 1 : 2 in some of the axes; we only know that they pertain to a common series.

Staurotide alone offers a choice between three uncertainties. The occurring form is a prism of 129° 20′ and this is usually

* The evidence as to the isomorphism of oxygen and fluorine, as shown by the relations of Andalusite and Topaz both in form and composition, were first pointed out by the author in vol. ix, p. 407, 2nd Series, of this Journal, and afterwards in his Mineralogy, 3d edition, 1850, p. 366.

taken as the unit vertical prism. A prism with the longer lateral axis *half* as long, has the angle 93° 8′, and this approaches the prism of Andalusite; and as the frequency of occurrence of a plane is no sure proof that the plane is necessarily of the fundamental series, we may with some reason assume the prism of 93° 8′ to be the fundamental one. But Staurotide forms twins in two directions, or parallel to two planes, and neither of these planes, referred to the above fundamental forms, has a simple ratio or expression, and this, notwithstanding the general fact that the faces of composition are of the highest value in ascertaining the directions of axial sections: moreover, one of the planes has the unusual symbol $\frac{3}{2}\breve{\frac{3}{2}}$ if referred to the prism of 129° 20′, and $\frac{3}{2}\breve{\frac{3}{4}}$ if referred to that of 93° 8′. Now, if instead of halving the longer lateral axis, we take *two-thirds* for the new axis *c*, then the expression is of the simplest kind in every respect. The following are the angles and symbols of the planes according to these three methods:—

	$a : b : c$
A.—Prism $I = 129° 20′$; $1\bar{i} = 69° 16′$; $\frac{3}{2}\breve{i}$ (one face of composition) $= 88° 24′$; $\frac{3}{2}\breve{\frac{3}{2}}$ other face of composition.	1·4478 : 1 : 2·11233
B.—Prism $I = 93° 8′$; $2\bar{i} = 69° 16′$; $\frac{3}{2}\breve{i}$ (one face of composition) $= 88° 24′$; $\frac{3}{2}\breve{\frac{3}{4}}$ other face of composition; $1\bar{i} = 108° 12′$; $1\breve{i} = 111° 10′$.	0·7239 : 1 : 1·05617
C.—Prism $I = 109° 14′$; $1\bar{i} = 69° 16′$; $1\breve{i}$ (one face of composition) $= 88° 24′$; 1 other composition face.	1·4478 : 1 : 1·40822

In the last, the planes, and the faces of composition have all a unit ratio, and it affords the simplest possible view of the crystallization. Whether regarded as the fundamental form or not, the relation to andalusite is shown by the fact of the two belonging to one and the same series or system of ratios.

Topaz has $I : I = 124° 19′$ and 55° 41′, and $i\breve{2} : i\breve{2} = 86° 52′$ and 93° 8′. The two prisms might either be taken as the fundamental, with nearly equal propriety. If the first be so taken, and the macrodome of 58° 31′ be the unit one, the axes are $a : b : c =$ 1·89774 : 1·05625 : 2 (= 1·7587 : 1 : 1·8936), *a* being treble what it is in Table I, and *b* double, the *b* also becoming *c* or the longer lateral axis. If the unit macrodome is that of 96° 2′, the axes are the same except that *a* is half as long.

Lievrite is usually considered as having for its fundamental vertical prism, a prism of 111° 12′. Now this angle is near 109° 14′ for Staurotide, (type C); and taking $i\bar{\frac{4}{3}}$ as the vertical prism *I*, the angle is near that of Andalusite. Moreover the species has near relations in its domes to the species of Table I, and none to those of Table III. Besides, in composition it resembles Andalusite and the allied species, in having less oxygen in its silica than in its bases. These facts afford some reason for placing the species where it stands in Table I.

The following are notices of other species in Table I:

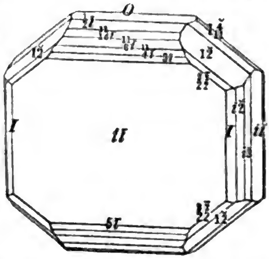
Chondrodite has for the summit angle of $1\bar{i}$, in its three types, 68° 32, 64° 54′, 70° 29′, giving as the mean 67° 58′, from which the mean for $\frac{1}{2}\bar{i}$ (taken as $1\bar{i}$ in the table) is 106° 52′, and the extremes 103° 28′ and 109° 26′. The angle for $1\bar{i}$ in the New Jersey chondrodite is 68°. The great difference of angle for these varieties of a single species should be considered, when judging upon the differences among the several species in the table. Taking $1\bar{i}$ above as the unit dome, the vertical axis is twice that given in the table, or 1·48352. In *Chrysolite*, also, we have as good reason for doubling the vertical axis, in which case it becomes 1·2584. In *Caledonite*, the occurring brachydome has the angle 70° 57′, and taking this as a unit dome, axis $a=$ 1·53136.

The relations of *Polianite* to Göthite and Diaspore appear to sustain the conclusion of Volger, cited in the American Journal of Science, vol. xvii, p. 213.

Euchroite is generally placed in a different position, and the prism 117° 20′ (form $1\bar{i}$) is made the fundamental vertical prism. But it forms no stellate or hexagonal twins like species of that angle, and nothing appears to sustain that view in preference to the one above taken.

Bournonite has the same relation to the species of Section II, that Antimony Glance has to those of Section I. It has very nearly the angles of Topaz.

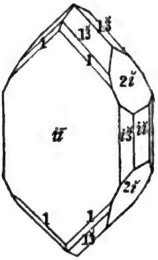
Wöhlerite has quite recently been studied by the able crystallographer of Paris, M. Descloizeaux.* He gives for the vertical prism, the angle 108° 56′. But by comparing the range of angles with those of the above species, it appears that its true relations are exhibited by the position in the annexed figure, which is altered from Descloizeaux. This gives for the vertical prism, the angle 90° 54′, and for the unit domes, the angles 108° 2′ and 108° 56′, very near Andalusite. It appears to be generally true that when a species affords for the prisms of two axes, angles (measured over the extremity of the other axis) nearly alike, this other axis is the true vertical, and the vertical prism is near 90° in angle.



Polymignite is near Wöhlerite in its crystallization. With the fundamental form adopted, the known octahedron is $2\bar{2}$ ($2P\bar{2}$), and the occurring prisms are $1\breve{i}=109°\ 46'$, $2\breve{i}=70°\ 50'$, $4\breve{i}=39°\ 9'$.

Polycrase affords angles in three directions near 90°, whichever position be taken. In the figure annexed, the position and lettering cor-

* Ann. de Chim. et de Phys., vol. xl, 3d series.



respond to the dimensions given in the table. Should we change it, and make the brachydiagonal the vertical axis, then :

$I = 93° 52'$, $1\bar{\imath} = 91° 29'$, $1\breve{\imath} = 95° 2'$.

And, again, if we make the macrodiagonal the vertical axis :

$I = 91° 29'$, $1\bar{\imath} = 84° 58'$, $1\breve{\imath} = 86° 8'$.

The symbols of these planes in these three positions (which we may call A, B, C,) are as follows :

A (figure)	1	$1\breve{3}$	$2\breve{\imath}$	$i\bar{\imath}$	$i\breve{3}$	$i\breve{\imath}$
B	1	3	$i\breve{2}$	O(base)	$3\breve{\imath}$	$i\breve{\imath}$
C	1	$1\breve{3}$	$\frac{1}{2}\breve{\imath}$	$i\bar{\imath}$	$\frac{1}{3}\breve{\imath}$	O (base)

The form is near that of Bournonite. It is also related distantly to the Columbite species, the prominent difference being *five degrees* in the angle of the vertical prism.

The species of Table II. fall into four sections, depending on the angles of the unit domes.

TABLE II.

Angle of the Vertical Prism I near 102°.

	Prism I.	Dome $1\bar{\imath}$.	Dome $1\breve{\imath}$.	Axes $a : b : c$.
I.				
Valentinite, - - - - -	(½) 103° 30′	58° 17′	70° 32′	1·7934 : 1 : 1·2683
Heavy Spar, - - - - -	101° 40′	63° 40′	74° 36′	1·6107 : 1 : 1·2276
Anglesite, - - - - - -	103° 38′	62° 42′	75° 29′	1·6415 : 1 : 1·2715
Leadhillite, - - - - -	103° 16′	60° 20′	72° 34′	1·7205 : 1 : 1·2632
Celestine, - - - - - -	104° 2′	62° 39′	75° 52′	1·6432 : 1 : 1·2807
Anhydrite, - - - - - -	102° 56′	61° 25′	72° 38′	1·6836 : 1 : 1·2557
Tantalite, - - - - - -	101° 32′	($2\bar{\imath}$) 64° 7′	($2\breve{\imath}$) 74° 58′	1·5967 : 1 : 1·2247
Mascagnine, - - - - -	107° 40′	65° 52′	83° 6′	1·5437 : 1 : 1·3680
Atacamite, - - - - -	97° 2′	67° 40′	74° 20′	1·4919 : 1 : 1·1310
Sulphur, - - - - - -	101° 58′	($\frac{2}{3}\bar{\imath}$) 65° 18′	($\frac{2}{3}\breve{\imath}$) 76° 40′	1·5606 : 1 : 1·2342
" - - - - - -	"	($1\bar{\imath}$) 46° 16′	($1\breve{\imath}$) 55° 36′	2·3408 : 1 : 1·2342
II.				
Orpiment, - - - - - -	100° 40′	73°	83° 30′	1·3511 : 1 : 1·2059
Dimorphine (I.), - - - -	98° 6′	75° 40′	83° 40′	1·2876 : 1 : 1·1526
" (II.), - -	100° 32′	74° 2′	84° 24′	1·3262 : 1 : 1·203
Epistilbite, - - - - - -	(½) 100° 58′	($\frac{1}{2}\bar{\imath}$) 70° 50′	($\frac{1}{2}\breve{\imath}$) 81° 30′	1·4063 : 1 : 1·2121
Childrenite, - - - - -	104° 14′	73°	87° 14′	1·3514 : 1 : 1·2853
III.				
Prehnite, - - - - - -	99° 56′	($2\bar{\imath}$) 89° 45′	99° 41′	1·0044 : 1 : 1·1904
Columbite, - - - - - -	100° 40′	86° 45′	97° 28′	1·0584 : 1 : 1·2059
Wolfram, - - - - - -	101° 5′	88° 6′	99° 13′	1·0337 : 1 : 1·2149
Mengite, - - - - - -	100° 28′	87° 24′	97° 54′	1·0463 : 1 : 1·2071
Brookite, - - - - - -	100°	83° 14′	93° 16′	1·1260 : 1 : 1·1918
Scorodite, - - - - - -	98° 2′	84° 40′	92° 43′	1·0977 : 1 : 1·1151
Hopeite, - - - - - -	101°	86° 38′	97° 40′	1·0607 : 1 : 1·2131
IV.				
Manganite, - - - - - -	99° 40′	114° 19′	122° 50′	0·6455 : 1 : 1·1847
Calamine, - - - - - -	103° 54′	116° 39′	128° 26′	0·6170 : 1 : 1·2776
Haidingerite, - - - - -	100°	118° 32′	126° 58′	0·5945 : 1 : 1·1918
Brochantite, - - - - -	104° 10′	($2\bar{\imath}$) 114° 29′	126° 41′	0·6434 : 1 : 1·2838
Cotunnite, - - - - - -	99° 46′	118° 28′	126° 44′	0·5953 : 1 : 1·1868
? Mendipite, - - - - -	102° 36′			x : 1 : 1·2482
? Jamesonite, - - - - -	101° 20′			x : 1 : 1·2203

I. Angle of macrodome near 60°, and brachydome near 71°.
II. Angle of macrodome 70° to 75°, or near the brachydome of Section I.
III. Angle of macrodome 83° to 90, or near the brachydome of Section II.
IV. Angle of macrodome 114° to 120°.

In Section I, the angles of the domes oscillate from or about the monometric angles 60° and 70° 32′. In Section III, 90° is nearly a mean between the angles of the domes. In Section IV, 120° is a similar mean for the domes. Section II is intermediate between I and III, the macrodome corresponding with the brachydome of Section I, and the brachydome with the macrodome of Section III. The vertical axis in Section III is *two-thirds* that of Section I; and by taking $\frac{3}{2}\bar{\imath}$ as $1\bar{\imath}$, the two groups would coalesce. The vertical axis of Section IV is about *two-fifths* of that of I.

In Section I, a macrodome of 60° and a brachydome of 70° 32′, both monometric angles, necessarily imply a vertical prism of 101° 34′. Hence the important fact, that *prisms approximating to* 101° 34′ *are of common occurrence, and a necessary result of the relations pointed out to Monometric forms.* This affords a sufficient reason for the occurrence of so many species near 102° in angle, just as there are many near 90°, and gives special importance to this value of $I : I$. Such prisms have approximately

$$a : b : c = 1 : \sqrt{\tfrac{1}{3}} : \sqrt{\tfrac{1}{2}}.$$

Valentinite affords an interesting exemplification of the general principle. Oxyd of antimony is a known example of dimorphism, occurring in *regular octahedrons* as *Senarmontite* and in *rhombic prisms* as *Valentinite.* It would hardly be expected that the latter should retain closely any of the angles of the former; and yet there is a brachydome having exactly the angle 70° 32′. The cleavage vertical prism has the angle 136° 58′, which gives for the prism with half the macrodiagonal, 103° 30′,—a relation like that between hornblende and augite. The three unit prisms, 103° 30′, 58° 17′, 70° 32′, very nearly correspond to the typical value of the axes $1 : \sqrt{\tfrac{1}{3}} : \sqrt{\tfrac{1}{2}}$.

It is of interest in this connexion to compare *Epistilbite* with Valentinite. It presents the vertical prism 135°, corresponding to 136° 58′ of Valentinite; and there is a macrodome of 109° 46′, whence another macrodome $2\bar{\imath}$ = 70° 50′, or very nearly the angle of the brachydome of Valentinite. It gives for $i\breve{2}$ the angle 100° 58′, as mentioned in the table. The occurrence of these Monometric angles has, beyond doubt, a profound significance. We hereby perceive in what respect Section II is related to Sections I and III. The oscillations from the typical angles of the group amount to about 5°.

Other species in Table II require special remarks.

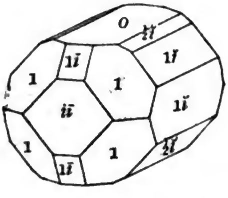
In *Sulphur*, the unit macrodome of authors has the summit angle 46° 18′. But taking $\frac{2}{3}\bar{i}$ as the unit dome, the angle is near that of Barytes and the other sulphates, as in the table; $\frac{1}{3}\bar{i}$ in sulphur is near $\frac{1}{2}\bar{i}$ in Barytes. *The homœomorphism of sulphur and the sulphates* (RO, SO^3) *is hence evident.*

Orpiment (sulphuret of arsenic) differs from sulphur in pertaining to Section II. The sulphur and arsenic compounds present a like amount of difference; and, further, they show that the fundamental vertical prism is that of 100° 40′, instead of that of 117° 49′, adopted by some authors. The difference in the unit domes of sulphur and orpiment is about $7\frac{1}{2}$ degrees, and the difference in the sulphurets and arseniurets or arseniosulphurets is nearly as large, or 5 to 6 degrees.

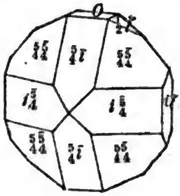
The arseniuret of iron (Leucopyrite or Lölingite) has been hitherto described as having a vertical prism of 122°, and the arsenio-sulphuret (mispickel) an angle of 112°, and the sulphuret (marcasite) of 106°. But the writer has been informed by R. P. Greg, Jr., that he has measured crystals of the arseniuret, and found the angle the same as for the arsenio-sulphuret. The difference of 6 degrees is, therefore, the full difference due to the arsenic; and where arsenic is present with sulphur in these compounds, the sulphur is wholly overpowered by the arsenic; just as in the sulphato-carbonates, the sulphuric acid dominates completely over the carbonic acid, the angle agreeing closely with that of the sulphates (anglesite), instead of being half way between those of the carbonates and sulphates.

Dimorphine, a sulphuret of arsenic of undetermined composition, falls into the same group with orpiment, and is near it in angle. Professor Scacchi, in describing dimorphine,* recognises the fact that it affords two angles approaching those of orpiment, viz. 83° 40′ and 117° 48′; and he adds correctly, that they do not, however, correspond in position in the two species. But on examining further his type I, and viewing the form in a different position, we find that there are two prisms, which taken as domes give the angles at summit 83° 40′ and 75° 40′ (angles $o:o$ and $e:e$ in Scacchi, pl. 12, f. 4, or $1\bar{i}$ and $1\breve{i}$ in the annexed figure 1); and these angles are so near two domes in orpiment that we can hardly hesitate as to regarding this the right position for the figures. We here make B of Scacchi the terminal plane O; A, the plane $i\bar{i}$; C, the plane $i\breve{i}$; also o^2 is $\frac{1}{2}\breve{i}$, and m is 1 or the unit octahedron. In Scacchi's type II (figure 2, above), the planes referred to the same fundamental form, are $\frac{5}{4}\bar{i}$ (e of Scacchi, fig. 13, pl. 4), $i\bar{\frac{5}{4}}$ (i), $\frac{5}{4}\bar{\frac{5}{4}}$ (m), $\frac{1}{2}\breve{i}$ (o^2).

1.



2.



* Memorie Geolgiche sulla Campania per A. Scacchi, Napoli, 1849, p. 120.

In this type, the angles, as given in the table, are almost identical with those of Orpiment. The axes become for

$$\begin{aligned} & \qquad\qquad\qquad\qquad\qquad b=1 \qquad\qquad\qquad\qquad a=1 \\ \text{Type I, } & a:b:c = 1{\cdot}2876 : 1 : 1{\cdot}1526 = 1 : 0{\cdot}77661 : 0{\cdot}89526. \\ \text{Type II, } & a:b:c = 1{\cdot}3262 : 1 : 1{\cdot}2030 = 1 : 0{\cdot}75405 : 0{\cdot}90707. \end{aligned}$$

The ratio $\frac{5}{4}$ in Type II loses its improbability, if any there be, when it is observed that *the domes of this ratio have approximately the angles of the unit domes of sulphur* or of the section to which sulphur belongs, they being $\frac{5}{4}\bar{i} = 62° \ 12'$ ($e:e$, f. 13, of Scacchi), and $\frac{5}{4}\breve{i}$ (not observed) $= 71° \ 56'$. They approach most nearly the unit domes of anhydrite.

Tantalite (FeO, TaO^3) has very nearly the dimensions of Barytes (BaO, SO^3), as seen in the table; and the fact is important, as it sustains the *homœomorphism of tantalic and sulphuric acids.*

Brookite was first observed to be homœomorphous with Columbite by Hermann. It differs by four degrees in its domes from that species, and has its vertical axis about one-twelfth longer.

In *Columbite*, it is of importance to note, that the face of twin composition is a plane of the brachydome $2\breve{i}$, in which the *basal* angle is about 120°; and in *Wolfram*, it is the brachydome $\frac{2}{3}\breve{i}$, in which the *summit* angle is about 120°.

Leadhillite has been shown by the writer to have close relations in angle to Anglesite, in this Journal, vol. xvii, p. 210. Its dimensions, as given in the table, exhibit still further this similarity of form. We reserve remarks on the forms of Leadhillite for another occasion.

Mascagnine diverges widely from the other sulphates in its vertical prism, and therefore also in its brachydome, while it agrees with them nearly in its macrodome.

We add a word on the unit-octahedrons of the species of Table II. The following are the angles for species in Sections I, III, and IV:

	Pyramidal Angles.		Basal Angle.
Section I.—Barytes, - - -	111° 38′	91° 22′	128° 36′
" Anglesite, - -	112° 13′	89° 41′	128° 54′
Section III.—Columbite, - -	117° 53′	102° 58′	107° 56′
" Brookite, - -	115° 42′	101° 34′	111° 26′
Section IV.—Manganite, - -	130° 49′	120° 44′	80° 22′
" Cotunnite, - -	133° 22′	123° 58′	75° 48′

It will be observed that there is an approximation to the angle of a regular octahedron only in one of the pyramidal angles of Section I, and in the basal angle of Section III.

TABLE III.

Angle of Vertical Prism, near 109° 28′.

	Prism I.	Dome $1\bar{i}$.	Dome $1\breve{i}$.	Axes $a:b:c$.
I.				
Marcasite, - - - - - -	106° 5′	64° 52′	80° 20′	1·5787 : 1 : 1·3287
II.				
Mispickel, - - - - - -	111° 53′	59° 14′	80° 8′	1·7588 : 1 : 1·4793
Leucopyrite, - - - - -	111° 30′			
Aurotellurite, - - - - -	110° 48′	($2\bar{i}$) 58° 52′	($2\breve{i}$) 78° 34′	1·7723 : 1 : 1·4496

The angle of the vertical prism in Table III is near the angle of a regular octahedron (109° 28′). As this prism is a cleavage prism, and the only distinct one in the species, it appears to be the true vertical prism.

But if we give the species another position, we may exhibit a relation to Sections II and III of Table II; and as they are all related to the species of those sections in composition, this relation is of fundamental interest. Making the brachydome $1\breve{\imath}$ the vertical prism, then the angle given above for the vertical prism is the new macrodome, and the supplement of that for the macrodome is the new brachydome. This gives for mispickel the angles $I : I = 99° 52'$; $1\bar{\imath} : 1\bar{\imath} = 111° 53'$; $1\breve{\imath} : 1\breve{\imath} = 120° 46'$. If we now double the length of the vertical axis, the dome 111° 53′ becomes $\frac{1}{2}\bar{\imath}$, and 120° 46′ $\frac{1}{2}\breve{\imath}$; and the three angles will be

$$I : I = 99° 52'; \; 1\bar{\imath} : 1\bar{\imath} = 72° 58'; \; 1\breve{\imath} : 1\breve{\imath} = 82° 40',$$

which are almost identical with the angles in Orpiment. The following table presents the angles and axes of the species thus changed in position, and also those referred to on Table II.

TABLE III. A.

	Prism I.	Dome $1\bar{\imath}$.	Dome $1\breve{\imath}$.	Axes $a : b : c$.
I.				
Sulphur, - - - - - -	101° 58′	65° 18′	76° 40′	1·5606 : 1 : 1·2342
Marcasite, - - - - - -	99° 40′	67° 12′	76° 24′	1·5049 : 1 : 1·1847
II.				
Orpiment, - - - - - -	100° 40′	73°	83° 30′	1·3511 : 1 : 1·2059
Dimorphine (I.) - - -	98° 6′	75° 40′	83° 40′	1·2876 : 1 : 1·1525
do. (II.) - - -	100° 32′	74° 2′	84° 24′	1·3262 : 1 : 1·2030
Mispickel, - - - - - -	99° 52′	72° 58′	82° 40′	1·3520 : 1 : 1·1890
Aurotellurite, - - -	101° 26′	71° 52′	83° 6′	1·3797 : 1 : 1·2225

It appears from the table that *Marcasite*, $Fe\,S^2$, is very near Sulphur in its angles and axes; while *Aurotellurite* $(Ag, Au), Te^2$, and *Mispickel*, $Fe(S, As)^2$, to which *Leucopyrite*, $Fe\,As^2$, should be added, have the form nearly of Orpiment. It is a question, therefore, whether Table III should not be suppressed, and the species annexed to Sections II and III of Table II. The cleavage constitutes the main reason for regarding the species as a separate Group. But notwithstanding the peculiarity in this respect, the affiliation with Sulphur and Orpiment is undoubted.

In Table IV. we recognize four sections:

I. Angle of macrodome near 70° 32′.
II. Angle of brachydome near 109° 28′.
III. Angle of macrodome near 109° 28′.
IV. Angle of brachydome near 120°.

The vertical axis in Section II is about one-fourth shorter than in Section I; in the latter $\frac{3}{4}\bar{\imath} = 85° 40'$, which approaches $1\bar{\imath}$ in the former, being very nearly the angle of Stephanite.

TABLE IV.

Angle of Vertical Prism, near 120° (115½°–120°).

	Prism I.	Dome $1\bar{\imath}$.	Dome $1\breve{\imath}$.	Axes $a : b : c$.
I.				
Sternbergite, - - - - -	119° 30′	69° 38′	100° 2′	1·4379 : 1 : 1·7147
II.				
Aragonite, - - - - - -	116° 10′	81° 40′	108° 26′	1·1571 : 1 : 1·6055
Cerusite, - - - - - -	117° 13′	80° 19′	108° 16′	1·1852 : 1 : 1·6388
Witherite, - - - - - -	118° 30′	77° 30′	106° 54′	1·2460 : 1 : 1·6808
Bromlite, - - - - - -	118° 50′	77° 18′	107° 5′	1·2504 : 1 : 1·6920
Stephanite, - - - - -	115° 39′	85° 5′	111° 8′	1·0897 : 1 : 1·5844
Nitre, - - - - - - -	118° 50′	80° 16′	109° 57′	1·1861 : 1 : 1·692
Chrysoberyl, - - - - -	119° 46′	$(\frac{3}{2}\bar{\imath})$78° 54′	$(\frac{3}{2}\breve{\imath})$ 109° 38′	1·2152 : 1 : 1·7239
Discrasite, - - - - - -	119° 59′	81° 22′	112° 12′	1·1638 : 1 : 1·7315
Copper Glance, - - } Stromeyerite, - - }	119° 35′	$(\frac{2}{3}\bar{\imath})$83° 56′	114° 10′	1·1117 : 1 : 1·7176
III.				
Herderite, - - - - - -	115° 53′	111° 42′	133° 58′	0·6783 : 1 : 1·5971
IV.				
Iolite, - - - - - - - -	119° 10′	94°	121° 38′	0·9325 : 1 : 1·7033
Mica, - - - - - - - -	119°–120°			

Chrysoberyl is very near Aragonite in angle, if the plane in the former usually regarded as $\frac{3}{2}\bar{\imath}$ be taken as $1\bar{\imath}$, as adopted in the table: otherwise the relation for the vertical axes of the two species is that of 3 : 2. So also *Copper Glance* approaches Aragonite, if what has been taken by authors as $\frac{2}{3}\bar{\imath}$ be regarded as $1\bar{\imath}$; otherwise the relation between them is that of 2 : 3. Such ratios, as we have elsewhere remarked, and the tables everywhere illustrate, are consistent apparently with homœomorphism in species. We have not sufficient data, at present, to decide whether the relation between Aragonite and Copper Glance is actually that of 1 : 1 or of 2 : 3, yet are inclined to believe the latter the fact; and if so, $1\bar{\imath}$ in Copper Glance has 61° 54′ for the summit angle, and 118° 6′ for the basal; the latter angle is near that of the vertical prism.

Many of the species in Tables II and III afford a horizontal prism or unit dome of 115° to 120°; and consequently, if this dome were taken as the fundamental vertical prism, the species would pertain to Table IV. Although we have not good reason for making the change, it is of some importance to view the species in this way, in order to apprehend more fully all the affiliations and relations of the forms. The author has alluded to Hausmann's comparisons by this method, of the anhydrous sulphates and carbonates; and he would here observe that the general review of Trimetric forms which he has made since his former paper was printed, and which has been here presented, has led him to give more importance to such comparisons than was implied in his paper in this Journal, vol. xvii, p. 210.

In the annexed Table the first column contains a statement of the particular dome in the preceding Tables which is here made the vertical prism; in some cases the angle of this prism is the supplement of that which is given for the dome in those Tables.

TABLE IV. A.

		Prism *I.*	Dome 1ī.	Dome 1ĭ.
From Table I.				
Chrysolite,	1ī	115° 36′	60° 48′	85° 57′
Do.	1ĭ	119° 12′	64° 24′	94° 3′
Triphyline,	1ī	118° 27′	58° 5′	86°
Do.	1ĭ	121° 55′	61° 33′	94°
Epsomite,	1ī	120° 4′	59° 27′	89° 26′
Do.	1ĭ	120° 33′	59° 56′	90° 34′
Diaspore,	1ī	115° 16′	61° 18′	86° 8′
Do.	1ĭ	118° 42′	64° 44′	93° 52′
Göthite,	1ī	113° 6′	62° 30′	85° 8′
Do.	1ĭ	117° 30′	66° 54′	94° 52′
Polianite,	1ī	115° 26′	62°	87° 8′
Do.	1ĭ	118°	64° 34′	92° 52′
Euchroite,	1ī	117° 20′	60° 47′	87° 52′
Do.	1ĭ	119° 13′	62° 40′	92° 8′
Topaz,	1ī	($\frac{2}{3}$) 115° 22′	61° 50′	86° 52′
Do.	1ĭ	($\frac{1}{3}$) 118° 10′	64° 38′	93° 8′
Bournonite,	1ī	($\frac{2}{3}$) 115°	61° 46′	86° 20′
Do.	1ĭ	($\frac{2}{3}$) 118° 14′	65°	93° 40′
From Table II.				
Valentinite,	1ī	121° 43′	76° 30′	109° 28′
Barytes,	1ī	116° 20′	78° 20′	105° 24′
Anglesite,	1ī	117° 18′	76° 22′	104° 31′
Leadhillite,	1ī	119° 40′	76° 44′	107° 26′
Celestine,	1ī	117° 21′	75° 58′	104° 8′
Anhydrite,	1ī	118° 35′	77° 4′	107° 22′
Tantalite,	1ī	115° 53′	78° 28′	105° 2′
Mascagnine,	1ī	114° 8′	72° 20′	96° 52′
Sulphur,	1ī	($\frac{1}{3}$) 114° 42′	78° 2′	103° 20′
Manganite,	1ī	114° 19′	57° 10′	80° 20′
Calamine,	1ī	116° 39′	51° 34′	76° 6′
Haidingerite,	1ī	118° 32′	53° 2′	80°
Brochantite,	1ī	114° 29′	53° 19′	75° 50′
Cotunnite,	1ī	118° 28′	53° 16′	80° 14′
From Table III.				
Marcasite,	1ī	115° 8′	73° 55′	99° 40′
Mispickel,	1ī	120° 46′	68° 7′	99° 2′
Aurotellurite,	1ī	121° 6′	69° 12′	101° 26′

Comparing the species in Table IV, A, with those of Table IV, we observe the following affiliations:

Marcasite and Aurotellurite are near Section I (Sternbergite).

From Valentinite to Sulphur (from Table II), are near Section II, (Aragonite Section).

From Chrysolite to Bournonite (from Table I), with also Manganite, are not coincident with either Section of Table IV, but they have approximately the ratio to the Aragonite Section of

4 : 3. This is the ratio between Chrysolite and Chrysoberyl. If 119° 12′ in Chrysolite be considered as corresponding to 119° 46′ in Chrysoberyl, then the macrodome of 64° 24′ in Chrysolite, if referred to the form of Chrysoberyl, would be $i\bar{\frac{4}{3}}$.*

From Calamine to Cotunnite, the vertical axis is to that of the Barytes series nearly as 5 : 3.

In reviewing the Groups of Trimetric forms, the most prominent fact observed is the prevalent approximation in the values of the angles of the unit prisms, to the three monometric angles, 90°, 109° 28′, and 120°, or their supplements, 70° 32′, and 60°; above all, the angles approaching 109° 28′ and 70° 32′ much predominate. When the vertical prism is near 90°, domes near 109° 28′ and 70° 32′, characterize very many of the species; while domes near 120° belong to the rest of the species. And in the second great group, macrodomes near 70° 32′, and 109° 28′, and brachydomes near 60° and 120°, determine the vertical angle of the prism, which approaches 101° 36′. Another large group has 120° and 60° as approximately the angles of the vertical prism.

The fact that the axial ratios 1 : $\sqrt{2}$ and 1 : $\sqrt{3}$ are typical of certain groups has been mentioned. It is easy to make out, in many cases, simple ratios between the axes, or the sum of two of the axes and the third; but the importance that should be attached to such ratios is questionable. The following are a few examples:

	Axes $a : b : c$	
Epistilbite (I=100° 58′),	1·4063 : 1 : 1·2121	$a+b=2c$.
Calamine, - - - -	0·6170 : 1 : 1·2766	$2a=c$.
Brochantite, - - - -	0·6534 : 1 : 1·2838	$2a=c$.
Cotunnite, - - - -	0·5953 : 1 : 1·1868	$2a=c$.
Haidingerite, - - -	0 5945 : 1 : 1·1918	$2a=c$.
Göthite, - - - - - -	0·6606 : 1 : 1·0888	$3a=b+c$.
Polycrase, - - - -	1·0265 : 1 : 1·0913	$2a=b+c$.
Valentinite, - - - -	1·7934 : 1 : 1·2683	$2a=b+2c$.
Sulphur ($1\bar{i}$), - - -	2·3408 : 1 : 1·2342	$a=b+c$.
" ($\frac{2}{3}\bar{i}$), - - -	1·5606 : 1 : 1·2342	$\frac{3}{2}a=b+c$.

In Valentinite this relation is evidently dependent on the more authoritative and equally exact ratio $a : b : c = 1 : \sqrt{\frac{1}{3}} : \sqrt{\frac{1}{2}}$.

Many conclusions bearing on chemical formulas, and the chemical relations of species, flow from the facts in the preceding tables. But we leave, for the present, that branch of the subject without further remarks.

* Since this paper was first printed, the author has found that M. Kengott of Vienna has recently pointed out similarities in the angles of Discrasite, Copper Glance, Antimony Glance, Bournonite, Chrysolite, Chrysoberyl, Tantalite, Topaz, Electric Calamine, Aragonite and Cerusite. But the true grounds of relation and distinction between these species, brought out in this paper, are not recognised.

ART. VI.—*On certain Physical Properties of Light, produced by the combustion of different Metals, in the Electric Spark, refracted by a Prism;* by DAVID ALTER, M.D., Freeport, Penn.

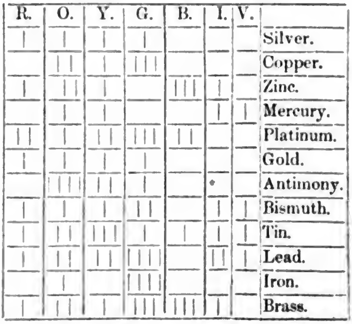
WE are indebted to the celebrated M. Fraunhofer for the fact, that the Solar Spectrum is crossed by numerous fixed lines, and that the light of some of the stars differs from that of the sun, in the number and situation of these lines.

In order to see some of these lines without the aid of a telescope, I ground a prism of flint glass, with large refracting angle, (74°). Viewing a fine slit made in sheet brass, when the source of light was the sky, nearly in the direction of the sun seen through this prism, I could count twelve or thirteen of Fraunhofer's dark lines. In viewing the blaze of a lamp, burning petroleum, I could discover neither dark nor bright lines, although I narrowed the light by passing it through the fine slit of sheet brass. I then tried the blaze of a tallow candle, when I could distinctly see an orange image of the blaze and one of faint yellow and one of green at the base of the blaze. The base of the orange image appeared to be the reflection of the light without any dispersion. When the brass with the fine slit is held in a horizontal position and the refracted light seen through it, is from the base of the blaze, bright bands, one of orange, one of yellow, one of green, one of blue, and one of violet, are seen.

The flame of alcohol is the same, except that the orange band is wanting. A slip of white paper shows the same bands when illuminated by a tallow candle. The jet of a blowpipe shows the five images still more distinctly.

The light from heated wire or charcoal shows no peculiarities. The electric spark from a Leyden Jar gave several bright images, which from optical illusion (perhaps from their brilliancy) appeared to extend beyond the sides of the spectrum, causing it to appear serrated along the edges.

But the most interesting effect of refraction, is from the spark caused by breaking the galvanic circuit, or at the break of a powerful magneto-electric machine. The machine I used produced sparks nearly half an inch in length. These sparks, viewed through the prism, appear almost wholly resolved into separate, colored bands, as illustrated in the annexed figure, where R is the red extremity of the spectrum, and V the violet.



Thus in the silver, there is in the orange a very bright band, one of yellow and one of green—two faint bands in the blue which are not always seen, and are probably caused by an impurity in the metal. The light which is not resolved into these bands is very faint except in the red.

The copper has two in the orange and three in the green—the other light appearing most distinct in the red and yellow. In the zinc there is a strong band of red, two of orange and three of blue with a faint yellow. The lead has two bright orange, and two in the yellow, nearer the orange than appears in the silver, then faint green bands and one bright violet, at the extremity of the spectrum.

Tin has a faint red, two of orange, three faint yellow, and a very faint green band, and also one of blue, indigo and violet.

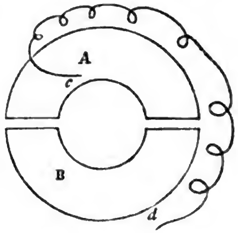
Iron exhibits a bright orange, four faint green, and sometimes two faint blue bands.

Bismuth a bright orange, a very faint yellow, two faint green, and a bright indigo.

Antimony some bright orange, and faint appearances in the yellow, green and blue.

Brass, a compound of copper and zinc, exhibits all the bands that are exhibited by these metals separately, i. e. one of red, one of orange, three of green, three of blue, one yellow and one indigo.

The preceding table presents these results, with some faint bands not above alluded to.



To illustrate better the manner of producing the sparks by the magneto-electric machine, I have annexed the following figure of the break. A and B represent two half circular discs of the metal intended to be used. One of these is connected with one end of the helix, and the other with the other end. They are fixed on the spindle of the revolving armature, and revolve with it. They are so placed, that the extremity *c* of the wire *c d*—which is stationary and rubs on them—is passed from the one to the other at the same time that the armature is passing the poles of the magnets.

In order to produce sparks, the end *d* of the wire is caused to rub on the discs, nearly opposite C—which causes a bright spark at each half revolution of the armature.

When the discs are of zinc, and the extremity *d* of the wire is of copper, the bands are the same as in brass, as also if the discs are of copper, and the wire zinc. When the discs and wire are both of copper, after having used a wire of zinc on the discs—they will still exhibit the same colored bands as the brass, until all the zinc left by the friction is removed, when the characteristic bands of the copper alone appear.

When silver and copper are used the bands are the same as with the silver alone, with the addition of two bands in the green, and so with any two metals, the bands are the same that both the metals exhibit when used separately, and the number of bands in the two metals will be equal to the number in both, except where they have bands that correspond in situation, in which case the bands of the two metals are blended together, producing bands of greater brilliancy. A spark between charcoal points does not show any peculiarity. The orange band appears to be common to all the metals tried—but I have not determined whether it occupies the same situation in the spectrum in all cases. The light of the spectrum not collected into the several bands, differs in intensity with the different metals—that with tin, iron and antimony being strong, while that of silver, copper and zinc, is faint.

Art. VII.—*Chinese and Aztec Plumagery;* by D. J. Macgowan, M.D.

Those natives of Northeastern Asia who in modern times have been drifted to the opposite shores of the Pacific were generally fishermen, mariners, or persons unacquainted with mechanical operations, and it is altogether probable that from the period of the first disaster by which they were driven to America, to that of the last shipwreck on that coast, very few artizans, and no scholars have in this manner changed continents; nor, judging from the low state of civilization of the more northern peoples, could it be expected that adventurers by the way of Behring's Straits or the Aleutian islands would carry with them a knowledge of any arts but the most simple and rudimentary. Hence, we shall look in vain for many resemblances in the industrial operations of the dwellers on the eastern and western coasts of the great ocean. Nevertheless, there is reason to believe that were we better acquainted with the state of arts amongst those farthest advanced in civilization in Polynesia and America, we should recognize modes of operation identical with those of China too numerous to be accounted for either as coincidences, or as independent inventions. A striking illustration is furnished by Capt. Wilkes,* who gives a drawing and description of an instrument for drilling holes, which he found in use by the inhabitants of Fakaafo or Bowditch island. This is undoubtedly a Chinese implement, being the most ingenious of all their tools. It is employed for perforating small holes by all workers in metals, but appears to most advantage in the hands of needle makers, who use it for drilling eyes in the small wires of which these are made.

* Narrative of the U. S. Exploring Expedition, by Capt. Wilkes, U.S.N., vol. v, p. 17.

Whether plumagery or the art of working in feathers, which was formerly practised in this part of the world, and also by the Aztecs of Central America, originated with Asiatics, or Americans, or with both, must be left to conjecture: in any view of the case, the fact is invested with interest. Attention was attracted to this subject by perusing the chapter devoted to an inquiry into Aztec civilization in Prescott's History of the Conquest of Mexico, where the distinguished historian shows that the ancient Mexicans excelled in the arts of plumagery and jewelry, in both of which they appear to have followed the same methods that are adopted by the Chinese.

Confucius informs us that in remote antiquity, ere the art of weaving silk or hemp was understood, mankind were clothed with the skins of beasts and feathers. How the latter were held together is not stated, but it must have been in a rude manner by cords or thread: at a later period feathers were in general demand as ornaments to banners and articles of attire; and subsequently for the manufacture of door-screens and caps. Tradition states that garments made of feathers and resembling fur dresses were presented to the emperor Shauhau, who reigned twenty-five centuries before our era. The earliest allusion to robes *woven* with feathers, occurs in the history of the Tsin dynasty. In the year 272 A. D., Dr. Ching, the court physican, presented the emperor with a gown made of feathers from the golden-headed pheasant. His Majesty being the founder of a new dynasty, was anxious to induce economical habits among his subjects; he therefore immediately ordered the splendid garment to be publicly burnt before the palace door, and issued on the following day stringent prohibitions against the presentation of articles of luxury.

The emperor Wuti, who flourished in the latter part of the fifth century, had a son who was notorious for his extravagance, having among other costly articles, a robe woven with peacocks' feathers. History further informs us that it was the custom of emperors to make presents every eleventh month of robes made out of the feathers of the variegated king-fisher to certain ministers of state. Taitsung, A. D. 976, changed the custom so far as to substitute silk for plumagery. Again, at a later period, the imperial records relate that the princess Ganluh engaged a skillful artificer to collect feathers of every description, to make of them two dresses, which should when looked at in front present one color, when viewed sideways another, and when held up to the light a third. When completed, she presented them to the empress, and they were so much admired that the fabric became very fashionable among officers and people, so much so that the hills and forests were swept clean of down and feathers, and vast numbers of birds were ensnared for their plumage.

More instances might be adduced to show that at different periods extending through many centuries plumagery was well understood. Garments thus manufactured were necessarily rare, their use being confined to persons of rank and wealth, and it may be doubted if even among the Aztecs whose country unlike China had vast forests crowded by the feathered tribe, the material was so abundant as to allow the inhabitants generally to shine in borrowed plumes.

The foregoing examples, drawn from the popular encyclopedias, throw no light on the mode of manufacturing this elegant material. Something however may be gathered on this subject from a work styled "New Conversations on things seen and heard at Canton," by a native of Suchau who spent many years in that city in a mercantile capacity in the latter part of the last century. In a short section devoted to *Bird Clothes*, he says, "There are several kinds of birds, the feathers of which are woven into a peculiar cloth by the southern barbarians. Among them is the celestial goose velvet, the foundation of the fabric being of silk, into which the feathers were ingeniously and skillfully interwoven, on a common loom, those of a crimson hue being the most expensive. Of these wild goose feathers, two kinds of cloth were made; one for winter, the other for summer wear. Rain could not moisten them; they were called 'rain satin,' and 'rain gauze' respectively. Canton men imitated the manufacture, employing feathers of the common goose, blending them with cloth. This fabric though inferior in quality was much cheaper. Goods of the same description were also brought from Hohlih [a state described by geographers as being adjacent to Samarcand, perhaps Bokhara] made of birds' feathers; they were twilled, the crimson colored being most valued. The article was too heavy for garments. The Cantonese also learned to imitate this, making it like plain silk, and inferior to that from abroad. Peacock feathers are employed by Canton manufacturers in making variegated threads which are used in making beautiful capes for females." Another writer states that a tribe of the Miaut, in Kwangsi, manufacture clothes from the fine down taken from the abdomen of geese. The down and tufts of birds were probably the materials which were woven into textile-like fabrics.

From the above, it would appear that the Chinese have lost the art of weaving feathers. Plumagery is still practised, however, in the decoration of metallic ornaments worn by all classes of females, chiefly on the head. When silver is employed, the article is first coated with gold. The gaudy lustre of the gilt is softened by laying over portions of it a covering of blue feathers representing flowers, insects, birds, and the like, which imparts indescribable beauty to the silversmith's elaborate filagrees. The art appears to most advantage as practised by artificers whose occupation is

the manufacture of garlands, chaplets, frontals, tiaras and crowns of very thin copper, on which purple, dark and light blue feathers of gorgeous brilliancy are laid with exquisite taste and skill. From the size of these ornaments great scope is afforded for the display of various figures. Sometimes two dragons extend from below the lobes of the ears, meeting above the forehead, the variegated scales of which are represented by minute portions of feathers of various hues; at others, beautiful flowers are interspersed with elegant mosaic, and then again the head attire appears animated, as with every turn of the fair one, tiny genii, birds, and insects are set in motion from springs and wires which retain them in the midst of the fairy-like garland. A more tasteful, elegant, or gorgeous blending of art and nature than is exhibited in one of these head dresses, perhaps no ingenuity has hitherto devised. To increase the effect, these ornaments are studded with pearls, produced cheaply and in great abundance by artificial means in a fresh water muscle. Commoner articles, such as earrings, and brooches for caps, are generally made of a small wreath of the forget-me-not, encircling one of these pearls. Half a dollar will purchase one of these when of silver, and a few cents the copper ones. The most expensive head dresses cost less than five dollars, unless of silver.

As this elegant art has not hitherto attracted the attention of foreigners, the mode of procedure should be described; this may be done in few words.

On the table at which the workman sits, he has a fasciculus of feathers, a small furnace with a few embers for keeping warm a cup of glue, a small cutting instrument like a screw-driver, a pencil or brush, and the articles, either silver, gilt, copper tinsel, or pasteboard which are to be feathered. The thumb and index finger being smeared with glue, the feathers are gently drawn between them, which stiffens the barbs, causing them to adhere firmly together; and when dry the perpendicular blade is drawn close to the shaft dividing it from the barbed portion. Holding this cutting implement as in writing *à la Chinoise*, the artist by pressing on the strips of barb with the knife, cuts them into the desired size and shape, which is a work of some delicacy—the pieces being very small, in the form of petals, scales, diamonds, squares, and the like, and requiring to be of the same size as the particular spot on which they are to be laid. Besides fingering this tool in the manner described, he holds the pencil nearly as we do a pen, dips it into the glue, brushes the spot to be coated, then expertly reversing it, touches with its opposite point a tiny bit of feather, which is thus lifted up and laid on the part for which it was fitted. Care is requisite also in giving a proper direction to this twilled work, for such of course is the appearance presented by the barbs.

The feathers most in demand for this purpose are from a beautiful species of *Alcedo*, brought from the tropical regions of Asia; they are employed for silver articles. King-fishers of coarser plumage, and less brilliant hue, found throughout the country, are used for ornaments made of copper or pasteboard. Blue always greatly predominates over lighter or darker shades, relieved by purple, white or yellow.

Whether Aztec silversmiths, whose ingenuity is so much lauded by the old Spanish chroniclers, practised this branch of plumagery or not is uncertain. There is reason to believe that what is said of their imitation of animals with moveable wings or limbs, of their representing scales of fish alternately of gold and silver, were nothing more than what is now done by the same craft in China; and which were esteemed very marvellous by Sir J. Mandeville (Voiage and Travaile), motion being communicated by wires and springs, and colors imparted by the plumage of choice birds. The construction of automata proper requires a knowledge of horological mechanism, never attained by either Chinese or Aztecs. Plumagery doubtless attained a far higher degree of excellence in Central America than in China, owing to the greater variety and extreme abundance of the feathered tribe in the dense and luxuriant forests of Mexico. Yet it is not likely that feather fabrics were so easily manufactured as to be worn by other than the nobles and affluent, to whom in China their use was confined. Had the Chinese been as destitute of textile fabrics as the Aztecs, they would unquestionably have engaged in plumagery with greater success.

Art. VIII.—*Binocular Microscope;* by Dr. E. D. North.

Common stereoscopy is a full perception of the solid forms of objects by a peculiar mode of viewing their geometric projections on a flat surface. Flat pictures are thus made to represent objects with a relief as perfect as that of the objects themselves, and, what is more than relief, give us the perception of *looking around and almost behind* each cylindrical or spheroidal form. Not only is a bust or statue thus seen, but several figures in a group stand forward at different distances from each other, while the clear space between is fully perceived and affords an especial gratification. In strict imitation of ordinary vision with both eyes, two drawings or photographs at the same distance are seen and are united by the brain, as if both eyes were looking at a single solid object without the intervention of an optical instrument. The success of the stereoscope may be pronounced perfect; the view by means of two drawings affords the same amount

of knowledge, and with as much accuracy and satisfaction as a view of a real object with both eyes.

At first thought it seems strange that the stereoscope was not sooner invented. A full detail of the reasons why in the progress of the human mind this invention is so late, and how it is that we are able to do without it, would open up a wide field of interesting considerations, and include the philosophical and aesthetical principles of the art of painting.* It will be sufficient to hint at these uses of vision by which the eye is the mind's instrument for mathematical or strictly scientific perception and knowledge. Such knowledge depends on *measurement;* solids are analyzed and measured by means of planes; the third dimension is in a plane at right angles to that of the length and breadth; it is length or breadth in another direction. In judging of length or breadth by the eye, we measure by a process of halving and repeated bisection, and make the eye a mathematical instrument; but in the case of an actual solid whose position we can change, if we would obtain the same accuracy of knowledge in regard to the third dimension, we must *turn the object over* until depth becomes length or breadth. If the object cannot be turned over, the dimension which, as it lies, is that of depth, cannot be measured accurately by the eye, and cannot, so to speak, be mathematically perceived; hence stereoscopic vision, either when it is natural, as being the simultaneous act of both eyes or as that obtained by successive focal changes of a single eye, or when it is effected by suitable optical instruments, cannot be what we call mathematical vision or that which is attended with measurement.

But optical instruments are useful not only for their assistance in measurement or strict science, but also as adjuvants of perception, and in obtaining an endless amount of less definite knowledge which is needed in the mixed sciences. Facility, rapidity, satisfaction and pleasure are also important considerations. This is especially true of the microscope, an instrument as essentially necessary and indispensable in science as the telescope, and equally accurate and reliable with it in all its revelations.

Inexperienced persons are embarrassed, when judging of objects under the microscope, by their appearing as flat pictures; by an inability to perceive depth, and by the care and slowness with which the mind must be employed when the focus is

* When the utmost possible minuteness and accuracy of discrimination is needed by a watch-maker, engraver, by any extremely accurate mechanic, or by a naturalist or other scientific man, but one eye is employed. Spectacles which are lenses of low power for both eyes, are used solely because an individual's eyes do not see at certain average distances as well as mankind's in general—never strictly speaking for magnifying an object too small for good eyes. First the closest inspection by a single eye is employed and at the shortest working distance of the eye; if the object be still too minute, a single hand lens, and never a pair of them, are resorted to. Attempts have been made to introduce watchmaker's magnifiers in spectacle frames; yet they have not come into use.

adapted to different planes; while in the common stereoscope the impression of a solid object is, as we have before said, absolutely perfect; so that when an object is deeper than it is long or broad it will infallibly appear so, and we are enabled even to measure the depth, to a certain extent, by comparing it with the length or breadth as a unit.

Professor Riddell has practically succeeded in adding to the previous powers of the microscope all those of the other instrument now so common and popular; and with this great superiority, that whereas the latter can exhibit only pictures and those of large objects, being thus dependent on the accuracy of the drawing, or the success of the photograph, his binocular microscope exhibits minute objects themselves with perfect accuracy and truth as they exist in nature; presenting them as solids in which the dimension of depth or thickness and their distance in superposition, is of as much importance to truth of perception as that of length or breadth. Fortunate in being able to commit his plans to a truly scientific and accurate workman, one to be depended on for resource and avoidance of error in the minute details necessary for applying a general idea, he has received from Mr. Grunow an instrument of great beauty of workmanship and convenience, the performance of which is most satisfactory in reference to the objects aimed at.

For a full description of the optical arrangement by which binocular vision is attained, we refer the reader to Prof. Riddell's article on the "Binocular Microscope," read before the American Association for the Advancement of Science, July, 1853, and published in No. 5, of the Quarterly Journal of Microscopical Science.

As far as we have been able to observe, this arrangement is not liable, in any degree, to the charge of pseudoscopy, nor is any perceptible chromatic or spheroidal aberration produced by the interposition of prisms, which is sufficiently proved by the examination of minute mercury-globules.

The mechanical arrangement is excellent. The instrument is mounted on a solid, and very steady tripod stand of cast-iron, with a plain stage 4×6 inches. The focussing is performed by a carefully wrought rack and pinion movement with two large milled heads.

The necessary movements for adapting the distance of the eye-lenses to any pair of eyes and for adjusting the prisms, so as to cause the rays from the objective, after being divided, to emerge coincident with the axes of the two compound bodies, are also performed by rack and pinion, and are so arranged that they act equally and at the same time on both the right and left side. The image is inverted in one direction, and two small rect. prisms placed above the eye-pieces, make it appear in its natural position and thus adapt the instrument for dissecting.

As the Professor possesses several higher objectives, by Mr. Spencer, he has had executed by Mr. Grunow, at the same time with the Binocular, only an object-glass of 1 inch focus with which alone we have had an opportunity of trying the performance.

This object-glass has a large angle and is corrected exquisitely for chromatic and spherical aberration. That difficult point in microscopy, a view into deep cavities, is perfectly attained. The eye of a fine needle by incident light, exhibited the walls of a cavity deeper than broad; an opened anther cell preserved in fluid and happening to lie edgewise, exhibited by transmitted light its walls with clear vision to the bottom of the depth; the fibres of the fringed end of a silk ribbon floated in space in different planes of superposition with an enlargement of distance in the perpendicular direction strikingly correspondent to their horizontal separation. No doubling or thickening of lines, mistiness, fog or uncertainty accompanied the views, but vision was brilliant and clear, while thus looking into space instead of being as it were confined by an optical wall of limitation, to a single plane. Neither while thus looking far into space by magnifying distance in proportion to surface, was any thing lost in power of minute discrimination of lines and edges; these were sharply and clearly defined: in short true shape and form were perceived in their actual proportions instead of being flattened, and an entire whole seen, as Schacht expresses it, "in optical sections;" and were exhibited simultaneously with minuteness of detail on surfaces.

Thus may we congratulate ourselves that binocular vision, so long a desideratum in microscopical science, is at length attained; constituting, as it does, the first important step since the solution of the great problem of the achromatising of the microscope, and the power of enormously enlarging the aperture of the objective.

New Haven, March, 1854.

Art. IX.—*Mechanical Action of Heat;* by W. J. Macquorn Rankine.

Gentlemen—I beg leave to address to you the following remarks on a formula referred to in the very able and interesting paper of Professor Frederick A. P. Barnard on "Heated Air considered as a Motive Power," published in the American Journal of Science for March.

The formula in question represents the maximum efficiency of a perfect Thermo-dynamic Engine: that is to say, the greatest fractional portion of the total heat consumed which such an engine converts into motive power; and, in Prof. Barnard's notation, it is as follows:

Let H represent the mechanical equivalent of total heat expended;

W, the motive power developed;

τ'', the absolute temperature at which heat is received by the elastic substance which works the engine;

$\tau_{,}$, the absolute temperature at which heat is given out;

Then the efficiency of the engine is

$$\frac{W}{H}=\frac{\tau''-\tau_{,}}{\tau''} \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \qquad (A.)$$

This formula is ascribed by Professor Barnard to Professor William Thomson of Glasgow.

The formula originally proposed by Professor Thomson is, however somewhat different in form from the above, being the following:

$$\frac{W}{H}=1-\varepsilon^{-\frac{1}{J}\int_{\tau_{,}}^{\tau''}\mu\, d\tau}; \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \qquad (B.)$$

where ε is the base of Napier's logarithms; J, "Joule's Equivalent" = 1390 foot-pounds per centigrade degree in liquid water; and μ, "Carnôt's Function;" being an unknown function of temperature only, which has to be determined by experiment.

This formula was deduced by Professor Thomson from a combination of Carnôt's principle, *that the efficiency of a perfect thermodynamic engine is a function solely of the temperatures at which it receives and emits heat*, with the law established experimentally by Joule, of the convertibility of the different forms of physical energy. It appeared in a paper on the Dynamical Theory of Heat, read to the Royal Society of Edinburgh in 1851, published in the 20th volume of their Transactions, and reprinted in the London, Edinburgh and Dublin Philosophical Magazine for 1852, Series 4th, volume 4th.

During the same session of the Royal Society of Edinburgh, there was read the Fifth Section of my paper on the Mechanical Action of Heat, in which, from the hypothesis that heat consists in certain molecular oscillations or revolutions, I deduced the law, *that the efficiency of a perfect thermodynamic engine is expressed by the difference between the absolute temperatures at which it receives and emits heat, divided by the greater of those absolute temperatures diminished by a constant which is the same for all substances;* that is to say,

$$\frac{W}{H}=\frac{\tau''-\tau_{,}}{\tau''-\varkappa}. \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \qquad (C.)$$

The constant $\varkappa$, if not absolutely inappreciable, is so small that no material error in practice can arise from neglecting it in com-

puting the efficiency of engines. This reduces the formula C to identity with A.

The section to which I have referred was published in the 20th volume of the Transactions of the Royal Society of Edinburgh, and re-printed in the London, Edinburgh and Dublin Philosophical Magazine for March, 1854.

Professor Thomson afterwards pointed out, (in consequence of a suggestion by Mr. Joule) that if Carnôt's Function be supposed to have the following value

$$\mu = \frac{J}{\tau} \quad \text{- - - - -} \quad \text{(D.)}$$

the formula B is transformed into A.

It is also obvious, that if Carnôt's Function have the value

$$\mu = \frac{J}{\tau - \varkappa} \quad \text{- - - -} \quad \text{(E.)}$$

B becomes identical with C.

Although the law expressed by the equation C, being partly founded on hypothetical principles, was at first to a certain extent conjectural, yet it has subsequently being so closely confirmed by the experiments of Messrs. Regnault, Joule, and Thomson, that it may be regarded as almost, if not altogether, demonstrated. It is still, however, uncertain, whether the constant $\varkappa$ has an appreciable value. The values computed from the experiments range from 0° to $2^\circ{\cdot}1$ Centigrade; absolute temperatures being reckoned from a point $274^\circ{\cdot}6$ Centigrade below melting ice, or $494^\circ{\cdot}28$ below zero on Fahrenheit's scale. The constant $\varkappa$ represents the position, on the scale of a perfect-gas thermometer, of the point of total privation of heat. If the elasticity of a perfect gas arises wholly from heat, then this point coincides with the absolute zero of a perfect gas thermometer, and $\varkappa = 0$.

It gives me much gratification to find, that the conclusion to which Mr. Joule, Professor Thomson, and myself have been led by our researches, as to the great economy of fuel to be expected from the Air-Engine when its practical difficulties have been overcome, is confirmed by the opinion of an investigator who has so carefully examined the subject as Professor Barnard.

59 St. Vincent street, Glasgow, 14th April, 1854.

ART. X.—*On the Resistance experienced by Bodies falling through the Atmosphere;* by ELIAS LOOMIS, Professor of Mathematics and Natural Philosophy in New York University.

AT the Cleveland meeting of the American Association, I presented a paper on the hail storm of July 1st, 1853, and introduced some computations for the purpose of determining the velocity which hail stones acquire in falling through the atmosphere. These results were based upon the experiments of Hutton respecting the air's resistance to bodies in motion, as determined by a whirling machine. Since the case of a body revolving about a fixed axis is different from that of a body descending freely through the atmosphere under the action of gravity, I have endeavored to test these results by experiments upon the direct fall of bodies. For this purpose I have performed various experiments upon the velocity acquired by falling drops of water; also by small spheres made of cork; and have experimented with lumps of ice varying from the size of a pigeon's egg up to masses weighing more than two pounds. These results coincided tolerably well with those obtained by computation from Hutton's data, but I refrain from publishing them at present in the hope of being able to repeat them with greater care and with the advantage of a greater elevation.

In the mean time I have sought for experiments of a similar kind made by other individuals. The experiments made at the request of Newton in St. Paul's Cathedral at London, seemed better suited to my purpose than any others I have found. There were two series of these experiments. In the first series, made in the year 1710, several hollow glass globes of about five inches in diameter were let fall from an elevation of 220 English feet, and the times of descent carefully measured. In the second series of experiments made in the year 1719, several bladders formed into spheres about five inches in diameter, were let fall from a height of 272 feet, and the times of descent carefully observed.

For the purpose of deducing from these experiments the coefficient of resistance, I proceeded in the following manner. It is evident that the resistance to a falling body beginning from zero, continually increases with the increasing velocity of the body; and since the impelling force is constantly the same, while the resisting force always increases, it must happen that the latter will at length become equal to the former. When this result takes place, that is, when the resistance is just equal to the weight of the body, there can be no further increase of velocity, and the body must thenceforth descend with a uniform motion. I found that in the first series of Newton's experiments, the velocity of

descent became sensibly uniform after a fall of 40 feet; and in the second series of experiments after a fall of 10 feet. I carefully computed the time of descent through the space just mentioned, and dividing the remaining distance by the remaining time of descent, obtained the terminal velocity, from which the coefficient of resistance is easily deduced.

In these computations I made use of Hutton's formulæ which are as follows:

$$\frac{4gcx}{w} = \text{h. log.}\ \frac{w}{w - cv^2} = \text{h. log. N.}$$

$$v = \sqrt{\frac{\text{N}-1}{\text{N}c}} \cdot w$$

$$t = \frac{1}{4g}\sqrt{\frac{w}{c}} \times \text{h. log.}\ \frac{\sqrt{\frac{w}{c}} + v}{\sqrt{\frac{w}{c}} - v}.$$

$$c = \frac{w}{v'^2}$$

Where

$c =$ the coefficient of resistance,
$g = 16\frac{1}{12}$ feet,
$w =$ the weight of the body expressed in ounces,
$x =$ the space fallen through,
$v =$ the velocity acquired in falling through the space x,
$t =$ the time of descent through the space x,
$v' =$ the terminal velocity of the body.

The following Table shows the results deduced from the first series of experiments with glass globes. Column first shows the weight of the globes in grains; column second shows their diameters in inches; column third shows the entire time of falling from a height of 220 feet; column fourth shows the velocity acquired in falling through a space of 40 feet; column fifth shows the time of falling 40 feet; column sixth shows the coefficient of resistance deduced from the time of descent; and column seventh shows the same coefficient reduced to a sphere of 5 inches in diameter by assuming the resistance to vary as the square of the diameter.

Weights of the globes.	Diamet'rs of the globes.	Whole times of falling.	Velocity in falling 40 ft.	Time of falling 40 feet.	Coefficient of resistance.	Do. reduced to a sphere of 5 in.
grains.	inches.	s.		s.		
510	5·1	8·2	28·237	1·9967	·0013845	·0013307
642	5·2	7·7	30·026	1·9386	·0015033	·0013899
599	5·1	7·7	30·070	1·9373	·0014033	·0013488
515	5·	7·95	29·183	1·9650	·0013014	·0013014
483	5·	8·2	28·383	1·9917	·0013133	·0013133
641	5·2	7·9	30·099	1·9364	·0015022	·0013888

In making these computations I was obliged to assume a probable value of c for the purpose of computing v and t; but the value of c deduced from the formula $c = \frac{w}{v'^2}$ is but slightly affected by an error in the first assumed value of c. In order however to eliminate even this small influence, having computed the value of c by these formulæ, I repeated the computation for v and t with the value of c thus deduced, by which means I obtained a second determination of c which is almost wholly independent of the first assumed value.

The mean of the preceding values of c for a sphere of 5 inches in diameter is ·0013455; whence for a velocity of 30 feet, which is about the terminal velocity in the preceding experiments, the resistance on a sphere 5 inches in diameter is 1·2109 ounces.

The following Table shows the results deduced from the second series of experiments with bladders, arranged as in the former table. The entire space fallen through was 272 feet. Columns four and five were computed for a descent of 10 feet.

Weights of the bladders.	Diameters of the bladders	Whole times of falling.	Velocity in falling 10 ft.	Time of falling 10 feet.	Coefficient of resistance.	Do. reduced to a sphere of 5 in.
grains.	inches.	s.		s.		
128	5·28	19	14·200	0·9955	·0013816	·0012390
156	5·19	17	15·581	0·9528	·0013376	·0012415
137·5	5·3	18·5	14·539	0·9844	·0014047	·0012501
97·5	5·26	22	12·375	1·0690	·0014223	·0012852
99·125	5·	21·125	12·911	1·0450	·0013308	·0013308

The mean of the preceding values of c for a sphere of 5 inches in diameter is ·0012693, whence for a velocity of 15 feet, which is about the terminal velocity in the preceding experiments, the resistance on a sphere 5 inches in diameter is ·2856 ounces.

In the year 1802, a great number of experiments on falling bodies were made by Benzenberg in the tower of St. Michael's church at Hamburg. Metallic balls about one and a half inches in diameter were allowed to fall from heights varying from 25 to 340 French feet, and the times of descent were measured by a watch having a hand which made one revolution per second. These experiments were performed with the greatest care; but since the specific gravity of the balls employed was more than ten times that of water, they do not appear to me as well adapted to indicate the amount of resistance, especially for small velocities, as the experiments of Newton.

Newton's experiments have furnished us the resistance on a sphere 5 inches in diameter, at the two velocities of 15 and 30 feet per second. We will now compare these results with those obtained by Hutton with the whirling machine. Hutton determined the resistance upon a sphere of pasteboard 6⅜ inches in diameter, for velocities from 3 to 20 feet per second. I have reduced these results to a sphere 5 inches in diameter by assuming

the resistance on spheres to vary as the squares of their diameters. I have also added the resistance to a velocity of 30 feet per second, computed upon the assumption that the resistance varies as the square of the velocity.

In the following Table, column first shows the velocity in feet per second; column second shows the resistance to a sphere 5 inches in diameter, moving with velocities expressed in the first column, deduced from Hutton's experiments with the whirling machine; column third exhibits the same numbers corrected so as to conform to the results of Newton's experiments.

Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.
feet.	ounces.	ounces.	feet.	ounces.	ounces.	feet.	ounces.	ounces.	feet.	ounces.	ounces.
3	·017	·014	8	·100	·080	13	·268	·214	18	·522	·417
4	·029	·023	9	·127	·102	14	·311	·249	19	·584	·467
5	·042	·034	10	·157	·126	15	·357	·286	20	·650	·520
6	·058	·047	11	·191	·153	16	·408	·326	30	1·487	1·211
7	·077	·062	12	·228	·182	17	·463	·370			

The resistances deduced from Newton's experiments at velocities of 15 and 30 feet per second are about one-fifth less than those obtained by Hutton. Diminishing the numbers in column second by one fifth part we obtain the numbers in column third which are presumed to represent the resistance in conformity with Newton's experiments.

If now we assume the specific gravity of ice to be 0·865 as given in the French Annuaire, the weight of spheres of ice 2, 1 and ½ inches in diameter will be as follows; and the greatest velocities which they can acquire by falling through the atmosphere are shown in the following Table.

Diameter of sphere.	Weight of sphere.	Terminal velocity.
2 inches.	2·0908 ounces.	98 feet.
1 "	0·2614 "	70 "
½ "	0·0327 "	49 "

Art. XI.—*The Brandon Tornado of January 20th*, 1854; by O. N. Stoddard, Prof. Chem. and Nat. Phil., Miami University, Ohio.

The whole breadth of the State of Ohio from Southwest to Northeast, was swept on the 20th of January, 1854, by a storm of unusual violence.

Traces of the same storm have been obtained from a point 27 miles N. E. of Little Rock, Arkansas, also from the western part of Pennsylvania. The whole length cannot be less than 800

miles. The breadth, I have not been able to determine. At Dubuque, Iowa, on the 20th of January, it was clear and very cold, with the wind from the N. W. At the point named in Arkansas, heavy rains from the southwest occurred on the 19th, followed by a clear and cold atmosphere on the morning of the 20th. On this day, the 20th, the storm passed over Ohio.

The temperature became mild on the 19th, and on the next day at noon, the thermometer stood at 70° in Cincinnati, and 68° in Oxford; the latter place more elevated than Cincinnati and about 30 miles from it, N. by W. The barometer fell gradually during the 19th, and rapidly on the 20th; and at 45 minutes past 12 M. the time when the storm began at Oxford, it stood 28·21; lower than at any period during the last twelve months. The air was saturated with vapor, and the walls of brick buildings were dripping with moisture. Three strata of clouds were distinctly observed: the highest cirri light and fleecy, moving towards the N. E.; the second, the proper storm-cloud in dark heavy masses, moving rapidly in the same direction; the third and lowest, the scud of sailors, flitting violently past, a little east of North. Along the track of this wind, there were at different times during the day, violent rains, vivid lightning, heavy thunder; and in some places large hailstones fell, though not in great quantity. In the northeastern part of the state the storm assumed the form of a tornado of great violence.

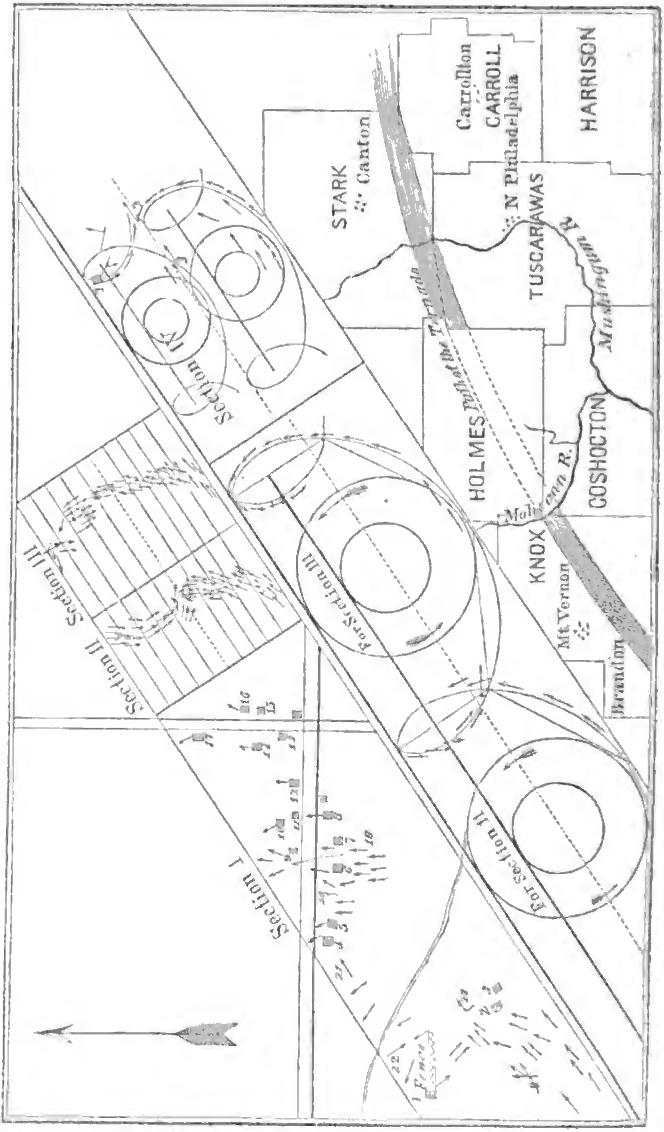
It first struck the earth in the S. W. part of Miller township, Knox County; N. Latitude 40° 18′, and Longitude 5° 30′ West of Washington.

Its course in that county was N. 56¼° E. Traces of it are found in some of the counties farther east; where its path gradually curved more towards the east; presenting its convex side to the north. The tornado in Washington Co. Pa., on the same day, was not probably a continuation of that in Ohio, as its location was several miles farther south. The track pursued in this state is given in the accompanying diagram.

It appears to have passed over one tier of counties without touching the earth, and subsequently to have descended again with its original force. The dotted lines exhibit its supposed path above the earth; the shaded part, the localities of its ravages on the surface.

The examination by the writer commenced one and one-fourth mile southwest of Brandon, at Dr. Baxter's barn, (marked 1, see diagram) the north gable end of which was crushed in, and the eastern half of the roof taken off and scattered to the S. East.

On the right were a barn and house (2, 3,) of E. Coleman, both of which were unroofed, and a rafter from the barn was driven through the side of the house and into a chest standing within.


HARRISON
CARROLL
Carrollton
N. Philadelphia
STARK
Canton
TUSCARAWAS
Muskingum R.
Path of the Tornado
HOLMES
Mohican R.
COSHOCTON
KNOX
Mt Vernon
Brandon
Section I
Section II
Section III
For Section II
For Section III

The tornado then crossed the valley of Sycamore creek, and ascending a gentle slope on the eastern side, struck Dr. Wheaton's house and barn, (4, 5,) which were utterly demolished. A brick church (6), a brick school-house (7), and a log house (8), were entirely swept from their foundations. A Presbyterian Church (9) was unroofed; a small frame house (11) had the roof and ceiling raised but not thrown off; an out-house (10) was destroyed; a stable (12) was also unroofed; a large frame house (13) was moved 18 inches from its foundations; a stable (14) carried 12 feet; a blacksmith and wagon shop (15, 16) and E. Squire's brick house (17) were prostrated. Some small buildings on the right, not represented, were unroofed or otherwise injured. About one-fourth of a mile east of Brandon it struck a dense forest. At this point a careful survey was made across the track; represented by Section II. For nearly three miles its course was mainly through the forest, with intervals of cleared land, uprooting or breaking almost every tree, and crushing the buildings which unfortunately stood in its way. Crossing the Newark and Mt. Vernon railroad, it swept over cultivated fields, destroying the few trees which had been left, and razing to the ground a stable and brick house. Three-fourths of a mile beyond this, an open grove of very large trees, mostly oak, stood on rising ground and in the line of the storm's axis. They seemed like an advanced guard to the forest a little farther in advance. The tornado struck them with appalling fury, and appeared well nigh irresistible. Scarcely one was left standing; some were uprooted, others broken, and split into fragments.

Near this place where it entered the forest, another survey was made (see Section III). In this survey, as well as the other explorations made during this day, the writer was aided by Rev. R. C. Colmery, of Mt. Vernon. A part of the forest here passed through was heavily timbered and covered with a dense undergrowth. Though the action of the wind was less symmetrical while struggling through and entangled among so many obstacles, yet the renewal of the velocity as fast as destroyed, and the force with which it plunged down and clung to the earth, were exceedingly interesting features of its workings.

Its path was followed several miles farther, in all about eleven miles, and occasional bearings taken, but as they corresponded entirely with the previous ones, no special record was made of them. The breadth of the track became somewhat less, but without any decrease in violence. Houses included in its vortex were still demolished; a horse was lifted into the air and carried over a fence; a cow was blown twelve rods against a tree, striking it twelve feet from the ground. In the vicinity of Gambier, after a course of twelve miles, its destructive influence was for a while suspended, till it again struck the earth in another county.

Having made these general statements, we may now examine more particularly the bearings of objects prostrated by the wind. The following table contains the bearings of a survey across the path of the tornado, 1¼ mile S. West of Brandon, commencing on the right. The plot of these bearings will be found in the left part of Section I.

	Course of the storm,	N. 56¼° E.	
1.	A tree, - - -	N. 56¼° E.	
2.	" - - - -	N. 45° E.	
3.	" - - - -	N. 56¼° E.	
4.	" - - - -	N. 22½° E.	
5.	Several trees, -	N. 45° E.	
6.	A tree, - - -	N. 22° E.	
7.	" overlying 6,	N.	
8.	" - - - -	N.	
9.	" across 8, -	N. 22° E.	
10.	" across 9, -	N. 56¼° E.	
11.	A fence, - -	N. 6° W.	This was near the middle of the track.
12.	A tree, - - -	N. 11¼° W.	
13.	A hickory, diagram (23)	N. 45° W.	The top after falling broken off and turned round to the East.
14.	Three oaks, - -	N. 45° E.	Near the hickory, but much smaller.
15.	Trees in orchard, -	E. 10° S.	
16.	Roof of Baxter's barn,	E. 45° S.	

A fence at this point, running east from Baxter's barn, was found to have been thrown along the western half towards the south, while the eastern half was prostrated northerly. This prostration of the halves of the fence in opposite directions, together with other peculiarities in the position of objects, induced the writer to believe that a secondary or double whirl existed at this place, the one on the right being in advance of the other.

The hickory was thrown down (Section 4, No. 2) across a ravine, and afterwards half of the tree, including the top, was turned round towards the east. The same current which produced this effect, prostrated three small oaks (3). The shingles from Baxter's barn (1) were first carried southeast, and then strewed for fifty rods in a curved line gradually bending in towards the course of the storm. The curved arrows from the barn correctly represent the arrangement of the shingles. Trees in an orchard near by were thrown down E. 10° S., coinciding in direction with the fragments from the barn.

The central whirl of the storm passing over the hickory and oaks, might account for their position, but not for that of the fence. The evidence from the latter of a secondary whirl, was as clear and explicit as well could be. Had the rails been removed by hand and laid on opposite sides, the result could not have been more regular. A secondary whirl about 60 rods in diameter, lagging a little behind the more extended one on the right, seems undeniable from the facts in the case.

To what extent this may have disturbed the general action, it is impossible to say. Its existence, if admitted, did not however

continue long, for all trace of it is lost in the forest one-fourth of a mile east of Brandon.

We will now examine briefly the action of the tornado at Brandon. The right hand part of this storm seems to have slid over that division of the town, merely prostrating fences and unroofing some small buildings. Its destructive effects were felt mainly in the middle and left hand portions.

A careful examination on the right of the path through the town, was not made; the approach of night cut it short: and the subsequent observations were given to a part of the track farther east. Section I represents that portion of the town most severely visited; and the arrows represent the direction in which objects were prostrated. The cluster of arrows (18) mark the position of trees in an orchard. Their direction was from N. to N. 10 W. Casting the eye from this point along the track of the storm, the buildings 7, 8, 12, 14, 15, 16, give the same general result. Combining them we obtain the mean N. 5° W. If we take another section farther to the left, commencing with the brick church (6) and extending nearly to Dr. Wheaton's house (5), we obtain a mean result of N. 15° 5′ W. From this estimate a tree (20) and the church (9) are rejected. No. 20 was an apple tree which had been twisted more than 45° after falling. The roof of the church was torn to fragments and scattered between N. E. and N. W. The direction in which the wind struck the church, can be made out with sufficient accuracy from other data. 1st, The south gable end was crushed in, and 2d, A bier was lifted from the grave yard, carried across the street along the line of the dotted arrow, and set down in the church yard.

The remaining objects on the left including Dr. Wheaton's house and barn, and the trees near the creek give a bearing of N. 33° 45′ W. From this 21 was rejected. It was a small oak, broken partly off, and turned round 90°. No. 22 was a limb from a tree carried S. 10° E.; supposed to be due to the reverse action of the storm. In the tabular view of these bearings given below, in order to fill it out for the right of the track, for which no materials existed in Brandon, the first three are interpolated from a survey farther west.

1.	N. 56¼° E.	5.	N. 15° 5′ W.
2.	N. 50° 37′ E.	6.	N. 33° 45′ W.
3.	N. 33° 45′ E.	7.	S. 10° E.
4.	N. 5° W.		

The bearings from this table are remarkable; and if the reader will construct a curve to suit them, he will find a singular correspondence with the cycloids which were planned with special reference to Sections II and III.

To these sections we will now turn. Section II represents a survey across the path of the storm, one-fourth mile east of Brandon, where it first struck the forest. The distances from bearing to bearing were not measured with a chain: it would have been impossible to use one in the midst of such a mass of fallen timber. They were determined, as nearly as could be, by the eye. On the right of the dotted line, the number of bearings might have been increased to any extent, as the ground was covered with fallen trees. The largest and straightest trees were selected. Those which were partially decayed or which had been thrown down by others were rejected. The arrows do not in every instance represent the relative distances of the trees from each other; in many cases they lie side by side in contact. On the left of the dotted line, they are sometimes placed nearer in the plot than was actually their position. The direction is accurately given. The arrows with cross-bars point out trees which lay across others. The prostrations appear to have been made almost entirely by the front of the tornado, with the exception of the left hand portion of the path, where the reverse action was frequently the most violent. This front action rendered the position of the trees more symmetrical, and the mode of action of the wind easier of solution. Objects thrown down at the first stroke of the current would accurately represent a tangent to the curve at that point, whatever the nature of the curve might be. As the trees which fell above others, must have been struck down after a part of the storm had passed, and cannot therefore exhibit the front action, they are on this account either rejected in obtaining the mean of the bearings, or included with others in the reverse action. The parallel lines were drawn to aid the eye in grouping the trees. Where the trees lie across them, they are included in that interval whose bearings most nearly correspond.

A tabular view of Section II, one-fourth mile east of Brandon,—¾ mile wide.

Course of the storm,		N. 56½° E.
1	group, - -	N. 45° E.
2	" - -	N. 34° E.
3	" - -	N. 8° 53′ E.
4	" - -	N. 10° 7′ W.
5	" - -	N. 23° W.
6	" - -	E.
7	" - -	E. 34° S.
8	" - -	E. 45° S.
9	" - -	E. 78° S.
10	" - -	E. 67° S.
11	" - -	S.

A tabular view of Section III, six miles east of Brandon,—¾ mile wide.

1	group, - -	N. 56° 15′ E.
2	" - -	N. 29° 24′ E.
3	" - -	N. 11° 15′ E.
4	" - -	N. 6° E.
5	" - -	N. 10° W.
6	" - -	N. 22° W.
7	" - -	N. 33° 45′ W.
8	" - -	N. 78° W.
9	" - -	W.
10	" - -	W. 45° S.
11	" - -	S.
12	" - -	S. 22° E.
13	" - -	S. 33° E.
14	" - -	S. 45° E.

The curtate cycloids were constructed to represent approximately these tabular views. The radius of the generating circle is to that which describes the curve as 1 : 2. The blanks in the

loop of either section could be supplied by interpolation from the other.

The barred arrows on the left of the loop in Section III designate trees which, though lying side by side with those on the opposite part of the same loop, yet rested with their limbs above the latter. The barred arrow in Section II which lies at the intersection of the curve was resting upon six large trees. An involute converging rapidly towards the centre might answer tolerably well the conditions of Section II, but it fails entirely when applied to Section III.

The involute action does not seem to have been distinctly marked. While passing rapidly over another part of the track, the bearings of scattering trees which were taken afforded more significant indications of the involute form near the axis. The relative distances in the latter case were not noted with sufficient accuracy to justify a projection.

The data thus far given are believed to be sufficient to enable the reader to form an intelligent opinion of the mode of action of this tornado. A few additional observations may afford some further aid.

1st. The space between the dotted line and the right hand border of the storm includes the path of most destructive violence. Within this limit almost every tree was prostrated or broken. This limit was clearly defined, especially on the left where the tornado first encountered the forest; but after plunging into it for some distance, its action became more obscure, and less symmetrical.

2d. On the left of the dotted line the force was much less violent, but trees enough were prostrated to determine the direction of the wind.

3d. No case was found of an object on the right thrown inward more than 11° or 12°. The mass of the trees on the right border lay parallel with the course of the storm.

4th. Along the dotted line, the trees generally lay N. 23° W.; making an angle of 79¼° with the general course of the storm.

5. Very few cases were observed of objects in the centre thrown forward in the direction of the path.

6th. There was no distinct case of the outward explosive action in buildings. The ascending current was, notwithstanding, very violent, for large objects were raised and transported several miles.

7th. Persons just outside of the path describe the storm as a column of vapor or smoke, whirling in indescribable confusion, accompanied with a deafening roar, so that the thunder, if any, was undistinguishable amid the general din and confusion.

8th. The atmosphere on the borders of the track appeared to suffer but little disturbance from the passage of the storm; and no current could be observed setting in towards it.

9th. There was scarcely any hail, but torrents of rain followed the tornado, equally, and perhaps, more abundant outside of the track than within it.

10th. The temperature sunk so rapidly that the next and succeeding days became marked as among the coldest in the month.

Rate of Progress.

Great discrepancy existed between different ooservers in reference to the progress of the storm. The estimated time of its passage over any one place varied from one-half to one and a half minutes. Mr. Coleman stated that he saw the whirling mass coming when three-fourths of a mile distant, and that he took scarcely five steps before he was struck down. If we take one minute as the time of its passage over any point, and three-fourths of a mile as the diameter of the storm, we obtain a velocity of 45 miles per hour.

I have not been able to obtain the barometric minima along the track of this extended S. West current; but if the lowest depression of the atmospheric wave passed near Little Rock, Arkansas, at noon on the 19th, then to have reached Oxford, Ohio, at 12½ P. M. on the 20th, would have required a velocity of nearly 29 miles per hour. My own opinion is that the first estimate is nearer the truth. The clouds during the forenoon of the 20th, flew past with a velocity which attracted special attention.*

In reference to the velocity of rotation an approximate estimate only can be reached. If the ratio of the progressive and rotary velocities adopted in the construction of the cycloid be correct, and 40 miles per hour be taken as the rate of progress, then the velocity of the wind on the right would have been 120 miles per hour. This velocity would be increased, especially near the axis, by the involute form of the curve; but to what extent this operated cannot be stated.

Another mode of estimating the force of the wind may be adopted. Among the oaks previously named as standing on rising ground, was one, a giant among giants. Its trunk was three feet in diameter and straight; its top symmetrical, and the whole sound to the core. It was shivered to fragments near the ground.

* Since writing the above, a communication from Mr. Raiff of Sandyville, northeastern part of Tuscarawas Co., states, that the tornado passed about 1 mile south of that place at *half past three* o'clock P. M.; moving in a direction north of east, but gradually curving towards the east. It commenced southwesterly about 2½ miles from Sandyville, and passed on to the east; in all a course of 17 miles. The direction corresponds with what has already been stated.

The roar of the tornado burst upon Brandon while the clock was striking 2 P. M. From this to Sandyville is 67 miles, which the storm swept over in an hour and a half; which gives a progressive velocity of 44⅔ miles per hour. This corresponds very closely with the previous estimate, the difference being only one-third of a mile. The mode of action seems to have been the same; parts of buildings, it is stated, were carried to the north, some to the southeast, and others to the west of the foundations.

Let us estimate the force necessary to break it. We will call the diameter $2\frac{1}{2}$ feet, the height 80 feet, the outline of the top a rectangle 50 feet by 40; and let us suppose the whole surface exposed to the wind to equal one-fourth of that included in the outline, or 500 square feet. Under these conditions the resultant of all the forces would act on the tree at a distance of 55 feet from the point of fracture. Taking the strength of oak at the usual standard, a force of 73,636 lbs. would be required to break the tree. If the surface exposed to the action of the wind be estimated at 500 square feet, the pressure upon each square foot would be 147 lbs. This gives a velocity of 172·9 miles per hour, equal to 253·5 feet per second. This is about one-fourth the velocity of a cannon ball. Though the above estimate gives an enormous force to the wind, yet I cannot perceive that any of the assumptions are exaggerated. The most doubtful point is the amount of surface supposed to be presented to the wind by the limbs, &c. The estimate is believed to be a large one, as the trees were at the time destitute of foliage.

Other circumstances are not wanting to sustain this view of a high rate of velocity in the tornado. A mass of brick cemented together, 4 feet by 3 and 1 foot thick, containing at least 12 cubic feet, and weighing more than 1000 lbs., was carried 15 feet from the wall of a house. A board was driven 3 inches into a charred oak stump. The writer pulled a shingle from an oak tree which had been driven into it one inch. An estimate of the force, in the aggregate, of this tornado, if made clear to the mind, by comparison with some well known standard, would excite astonishment. If any one will take the trouble to make the calcution, he will probably assent to the following: a section of it one half mile wide and 100 feet high, exerted a force equal to half the steam power of the globe. More than 50,000 trees were prostrated or broken by it in less than one half hour.

It is not my purpose to speculate upon any cause or causes which could generate such an enormous force. Ohio has been remarkable for the number and violence of its tornados during the winter. It is important to state another fact in this connection. A southwest wind has prevailed to an unusual degree this winter, and the tornados have been found imbedded in and moving with the general current. The writer has no theory to present in regard to their causes, or their mode of action. In the present case he has adopted that curve which the data seemed to demand.

In conclusion, the writer would take this occasion to acknowledge his obligations to those gentlemen at Brandon and Mt. Vernon, who afforded every aid in their power; also to the superintendents of the Cincinnati and Columbus, and the H. and D. railroads, who generously tendered him a free ticket for more than 300 miles of travel.

Art. XII.—*Considerations on the Group of Small Planets situated between Mars and Jupiter;* by M. U.-J. Le Verrier.*

We cannot doubt that our solar system is far more complicated than has hitherto been supposed. To say nothing of the immense number of comets which apppear to belong to this system, or of the meteors whose path lies near the orbit of the earth, we can still find in the asteroids situated between Mars and Jupiter, the catalogue of which goes on increasing each day, a fruitful subject of reflection and research.

In regard to the small planets discovered at the beginning of the present century, Olbers threw out the idea, that they were derived from the ruins of one larger planet. This hypothesis, which was based upon no very precise data, and which is inconsistent with the great inclination of the orbit of Pallas, must be abandoned; especially since the numerous discoveries of the last few years. Instead of explaining the existence of these bodies by supposing an alteration in the primitive system of the universe, we are now led to believe rather, that they have been formed regularly, like the others, and according to the same laws.

If these views are just, we ought to expect the discovery of a very large number of small planets; in proportion to the zeal with which observers shall extend their researches and to the possibility of employing more powerful instruments. The liberality with which astronomers, who have been recently engaged in these examinations, have submitted to the public their facilities of discovery, in the publication of costly ecliptic charts, has rendered this labor henceforth easy. The multiplicity of discoveries in this field, instead of diminishing the interest in them, is of a nature rather to enhance their importance. For if it has been necessary to give up the hypothesis of Olbers, it may be hoped at least that the knowledge of a great number of small planets will lead to the discovery of some law in their distribution, and to the determination of the configuration of their principal groups. It is hardly credible that these asteroids should be scattered promiscuously in all parts of the heavens: besides their having been discovered hitherto only in a single zone, we must suppose that the same cause which has brought together so much matter in each of the principal planets, has distributed all the rest also into separate and distinct groups.

We are acquainted at present with the orbits of *twenty-six* asteroids (omitting in these remarks the twenty-seventh just discovered by Mr. Hind). These twenty-six asteroids having been found under diverse circumstances and by different observers, are as we believe capable of furnishing some grounds for generaliza-

* From the Comptes Rendus, vol. xxxvii, p. 793.

tion upon the whole group to which they belong. This is what we propose here to examine.

The small planets revolve in a zone which begins at the mean distance of 2·20 from the sun and extends to the distance of 3·16; unity being here the mean distance of the earth from the sun.

The excentricities of the orbits are quite considerable; their mean rising to 0·155. The amount of excentricity in each one seems to bear no relation to the mean distance from the sun, or to the longitude of the perihelion.

The inclinations of the orbits, both with reference to each other and to the ecliptic, are also quite large. The mean of the sines of the inclination to the ecliptic is 0·155. The amount of the inclination in each one does not appear to depend either upon the mean distance from the sun, or upon the direction of the ascending node.

The perihelia and the ascending nodes present some special peculiarities. The perihelia of *twenty* of them, having their longitudes between 4° and 184°, are embraced in an extent of the heavens less than a semi-circumference. The ascending nodes of the orbits of *twenty-two*, whose longitudes are between 36° and 216°, are also comprised within less than half of the circumference of the heavens, and nearly coincident with the space occupied by their perihelia. Possibly we may trace a regular difference between the mean direction of the ascending nodes of the planets nearest to the sun and of those more remote, and so have ground for the conjecture that these asteroids belong really to two distinct groups. But we pass this by for the present. What has been said suffices for our present purpose; viz., *the determination of a superior limit of the total mass of matter that can exist in the zone of the heavens which we are considering.*

Such an investigation can be based only upon a close examination of the nature and amount of the influences exerted by this matter upon the nearer planets, Mars and the Earth. The different terms into which we commonly resolve these influences are not equally well suited to our object. The periodic terms, depending upon the relative situation of the planets influenced and the small masses which act upon them, neutralize each other, if there are a great number of asteroids situated at each instant in every part of the heavens: so that the sum total of the disturbing masses may be very considerable and yet neither Mars nor the Earth suffer annual and sensible perturbations.

The secular variations of the elements of the orbits do not depend upon the relative positions of the bodies, and consequently are not subject to the inconvenience which I have pointed out. Those of the terms of secular variation, which depend upon the longitude of the perihelia and nodes, may however present analo-

gous difficulties, which we can eliminate only by considering the terms in which the longitude of these elements does not enter, if such terms exist. Now the motion of the perihelion, whether of Mars or the Earth, actually contains a sensible term of this kind: this term depends only upon the mean distance of the asteroids from the sun and upon the excentricity of the disturbed planet; moreover it is essentially positive whatever may be that of the small planets whose action upon Mars and the Earth we are here considering, so that all these small masses combine by their action to impress direct motions upon the perihelia of the two principal planets here referred to. If then we suppose that the zone in which these small planets are found contains a very great number of others like them, we should conclude that the whole group acts upon the perihelia very nearly as if they were collected into a single mass situated at a proper mean distance, and we should deduce therefrom the means of determining the total mass, or at least a limit which it cannot exceed.

This subject however presents other difficulties. Besides the term upon which we have been reasoning there is a second in the expression of the motion of the perihelion, of the same mathematical order of magnitude as the first, but which depends upon the direction of the perihelia of the several disturbing masses: it is important to inquire whether it can modify the results furnished by the first term.

If the perihelia of the asteroids, known and unknown, were distributed uniformly in all parts of the zodiac, the second term of the motion of the perihelion of Mars or of the Earth might be neglected; because the action of those masses, whose perihelia are situated in one half of the heavens, would be destroyed in this second term by the action of those masses whose perihelia are in the other half. But we have seen that there is great liability to error in reckoning upon such a uniformity in their distribution; the perihelia of twenty out of twenty-six being placed in one-half of the heavens, a result doubtless not of chance and seeming to indicate that the matter whose mass we are investigating is nearer the sun on the side of the summer solstice than of the winter. This circumstance must be taken into consideration, not for the purpose of introducing it as an essential condition into the solution of the problem, but on the contrary of arriving at a result which shall be independent of it.

This consideration will lead us not to make use of the motion of the earth's perihelion although it is better known than that of Mars. The earth's perihelion being in fact situated in that very portion of the heavens occupied by the perihelia of more than three-fourths of the asteroids, the second term which enters into the expression of its motion may become appreciable as compared with the first and of the contrary sign: inasmuch as these

terms are respectively proportional to the excentricities of the terrestrial orbit and the orbits of the small planets. and as the excentricities of these last are at the mean nine times greater than that of the earth.

The perihelion of Mars is situated much more favorably in relation to the mean direction of the perihelia of the asteroids; and besides the excentricity of its orbit is greater. As a result of these two conditions united, the second term which enters into the expression of the motion of the perihelion is only one *fourth* of the first. Now this superiority of the first term may be expected to continue after the discovery of a great number of new asteroids, whether this predominance of the perihelia in the mean direction of the summer solstice shall be confirmed, as it probably will be, or whether we shall be obliged to return to the idea of a uniform distribution of them through every part of the heavens.

In accordance with these remarks I have found that if the mass of the whole group of asteroids was equal to the mass of the earth, it would produce in the heliocentric longitude of the perihelion of Mars an inequality which in a century will amount to eleven seconds. Such an inequality, supposing it to exist, surely could not have escaped the notice of astronomers. If we reflect that this inequality will become strikingly sensible at the moment of the opposition of Mars, we must believe that at present and although the orbit of Mars has not been determined with perfect accuracy it cannot nevertheless admit of an error in longitude greater than one-fourth of the inequality which we have pointed out. Hence we conclude that *the sum total of the matter constituting the small planets situated between the mean distances* 2·20 *and* 3·16 *cannot exceed about one-fourth of the mass of the Earth.*

Similar conclusions may be reached by considering the motion of the plane of the ecliptic; the result will depend however in that case upon the hypothesis that the ascending nodes of more than three-fourths of the orbits are situated in a semi-circumference. The limit moreover which we should reach in this way would not be so narrow. We stop then for the present with the result furnished by the consideration of the perihelion of Mars. More precision may be given to it by perfecting the theory of Mars, and by the discovery of new asteroids. Such as it is, it seems fitted to throw some light upon a subject in regard to which we have hitherto had no reliable data.

In a second memoir* the author establishes by a thorough investigation of the secular variations of the elements of the orbits the following propositions.

1. The excentricities of the orbits of the known asteroids can suffer only very small changes as the effect of perturbation.

* Compt. Rend., t. xxxvii, p. 965.

These excentricities which are now quite large, have then always been and will always remain large.

2. The same is true of the inclination of their orbits. So that the amount of excentricity and inclination answers to the primitive conditions of the formation of the group.

3. These propositions are true only for distances from the sun above 2·00. An asteroid situated between Mars and the distance of about 2·00 would not be *stable* in the meaning which is attached to that word in celestial mechanics.

Flora, which is nearest to the sun of the known asteroids, is 2·20 distant. The author observes that it is quite remarkable that a planet has been found almost up to the line which theory assigns as the limit of stability, and that none have been found beyond it. Must we believe that the same cause which has given origin to so many asteroids above the distance 2·00 has also distributed them below this distance? but that, the excentricities and inclinations of these last being considerably increased, it is at present difficult to discover them, especially because towards their perihelion, they will be immersed in the light of the sun, and that coming to their opposition only near their aphelia, they will then be too far from us?

4. Owing to the magnitude of the excentricities and the inclinations and the smallness of their variations, the mean motions of the perihelia and of the nodes are proportional to the times.

Art. XIII.—*On Electric Induction—Associated cases of Current and Static Effects;* by Professor Faraday, D.C.L., F.R.S.*

Certain phenomena that have presented themselves in the course of the extraordinary expansion which the works of the Electric Telegraph Company have undergone, appeared to me to offer remarkable illustrations of some fundamental principles of electricity, and strong confirmation of the truthfulness of the view which I put forth sixteen years ago, respecting the mutually dependent nature of induction, conduction, and insulation (Experimental Researches, 1318, &c.). I am deeply indebted to the Company, to the Gutta Percha Works, and to Mr. Latimer Clarke, for the facts; and also for the opportunity both of seeing and showing them well.

Copper wire is perfectly covered with gutta percha at the Company's works, the metal and the covering being in every part regular and concentric. The covered wire is usually made into half-mile lengths, the necessary junctions being effected by twisting or binding, and ultimately soldering; after which the place

* Phil. Mag., 4th Ser., vii, 197, March, 1854.

is covered with fine gutta percha, in such a manner as to make the coating as perfect there as elsewhere: the perfection of the whole operation is finally tried in the following striking manner by Mr. Statham, the manager of the works. The half-mile coils are suspended from the sides of barges floating in a canal, so that the coils are immersed in the water whilst the two ends of each coil rise into the air: as many as 200 coils are thus immersed at once; and when their ends are connected in series, one great length of 100 miles of submerged wire is produced, the two extremities of which can be brought into a room for experiment. An insulated voltaic battery of many pairs of zinc and copper, with dilute sulphuric acid, has one end connected with the earth, and the other, through a galvanometer, with either end of the submerged wire. Passing by the first effect, and continuing the contact, it is evident that the battery current can take advantage of the whole accumulated conduction or defective insulation in the 100 miles of gutta percha on the wire, and that whatever portion of electricity passes through to the water will be shown by the galvanometer. Now the battery is made one of intensity, in order to raise the character of the proof, and the galvanometer employed is of considerable delicacy; yet so high is the insulation, that the deflection is not more than 5°. As another test of the perfect state of the wire, when the two ends of the battery are connected with the two ends of the wire, there is a powerful current of electricity shown by a much coarser instrument; but when any one junction in the course of the 100 miles is separated, the current is stopped, and the leak or deficiency of insulation rendered as small as before. The perfection and condition of the wire may be judged of by these facts.

The 100 miles, by means of which I saw the phenomena, were thus good as to insulation. The copper wire was $\frac{1}{16}$th of an inch in diameter; the covered wire was $\frac{4}{16}$ths; some was a little less, being $\frac{7}{32}$nds in diameter; the gutta percha on the metal may therefore be considered as 0·1 of an inch in thickness. 100 miles of like covered wire in coils were heaped up on the floor of a dry warehouse and connected in one series, for comparison with that under water.

Consider now an insulated battery of 360 pairs of plates (4 × 3 inches) having one extremity to the earth; the water wire with both its insulated ends in the room, and a good earth discharge wire ready for the requisite communication: when the free battery end was placed in contact with the water wire and then removed, and afterwards a person touching the earth discharge touched also the wire, he received a powerful shock. The shock was rather that of a voltaic than of a Leyden battery; it occupied *time*, and by quick tapping touches could be divided into numerous small shocks; I obtained as many as forty sensible

shocks from one charge of the wire. If *time* were allowed to intervene between the charge and discharge of the wire, the shock was less; but it was sensible after two, three, or four minutes, or even a longer period.

When, after the wire had been in contact with the battery, it was placed in contact with a Statham's fuse, it ignited the fuse (or even six fuses in succession) vividly; it could unite the fuse three or four seconds after separation from the battery. When, having been in contact with the battery, it was separated and placed in contact with a galvanometer, it affected the instrument very powerfully; it acted on it, though less powerfully, after the lapse of four or five minutes, and even affected it sensibly twenty or thirty minutes after it had been separated from the battery. When the insulated galvanometer was permanently attached to the end of the water wire, and the battery pole was brought in contact with the free end of the instrument, it was most instructive to see the great rush of electricity into the wire; yet after that was over, though the contact was continued, the deflection was not more than 5°, so high was the insulation. Then separating the battery from the galvanometer, and touching the latter with the earth wire, it was just as striking to see the electricity rush out of the wire, holding for a time the magnet of the instrument in the reverse direction to that due to the ingress or charge.

These effects were produced equally well with either pole of the battery or with either end of the wire; and whether the electric condition was conferred and withdrawn at the same end, or at the opposite ends of the 100 miles, made no difference in the results. An intensity battery was required, for reasons which will be very evident in the sequel. That employed was able to decompose only a very small quantity of water in a given time. A Grove's battery of eight or ten pairs of plates, which would have far surpassed it in this respect, would have had scarcely a sensible power in affecting the wire.

When the 100 miles of wire in the air were experimented with in like manner, not the slightest signs of any of these effects were produced. There is reason, from principle, to believe that an infinitesimal result is obtainable, but as compared to the water wire the action was nothing. Yet the wire was equally well and better insulated, and as regarded a constant current, it was an equally good conductor. This point was ascertained by attaching the end of the water wire to one galvanometer, and the end of the air wire to another like instrument; the two other ends of the wires were fastened together, and to the earth contact; the two free galvanometer ends were fastened together, and to the free pole of the battery: in this manner the current was divided between the air and water wires, but the galvanometers were affected to precisely the same amount. To make the result more

certain, these instruments were changed one for the other, but the deviations were still alike; so that the two wires conducted with equal facility.

The cause of the first results is, upon consideration, evident enough. In consequence of the perfection of the workmanship, a Leyden arrangement is produced upon a large scale; the copper wire becomes charged statically with that electricity which the pole of the battery connected with it can supply;* it acts by induction through the gutta percha (without which induction it could not itself become charged, Exp. Res. 1177), producing the opposite state on the surface of the water touching the gutta percha, which forms the outer coating of this curious arrangement. The gutta percha across which the induction occurs is only 0·1 of an inch thick, and the extent of the coating is enormous. The surface of the copper wire is nearly 8300 square feet, and the surface of the outer coating of water is four times that amount, or 33,000 square feet; hence the striking character of the results. The intensity of the static charge acquired is only equal to the intensity at the pole of the battery whence it is derived; but its quantity is enormous, because of the immense extent of the Leyden arrangement; and hence when the wire is separated from the battery and the charge employed, it has all the powers of a considerable voltaic current, and gives results which the best ordinary electric machines and Leyden arrangements cannot as yet approach.

That the air wire produces none of these effects is simply because there is no outer coating correspondent to the water, or only one so far removed as to allow of no sensible induction, and therefore the inner wire cannot become charged. In the air wire of the warehouse, the floor, walls, and ceiling of the place constituted the outer coating, and this was at a considerable distance; and in any case could only affect the outside portions of the coils of wire. I understand that 100 miles of wire, stretched in a line through the air so as to have its whole extent opposed to earth, is equally inefficient in showing the effects, and there it must be the distance of the inductric and inducteous surfaces (1483), combined with the lower specific inductive capacity of air, as compared with gutta percha, which causes the negative result. The phenomena altogether offer a beautiful case of the identity of static and dynamic electricity. The whole power of a considerable battery may in this way be worked off in separate portions, and measured out in units of static force, and yet be employed afterwards for any or every purpose of voltaic electricity.

I now proceed to further consequences of associated static and dynamic effects. Wires covered with gutta percha and then inclosed in tubes of lead or of iron, or buried in the earth, or sunk

* Davy, Elements of Chemical Philosophy, p. 154.

in the sea, exhibit the same phenomena as those described, the like static inductive action being in all these cases permitted by the conditions. Such subterraneous wires exist between London and Manchester; and when they are all connected together so as to make one series, offer above 1500 miles; which, as the duplications return to London, can be observed by one experimenter at intervals of about 400 miles, by the introduction of galvanometers at these returns. This wire, or the half or fourth of it, presented all the phenomena already described; the only difference was, that as the insulation was not so perfect, the charged condition fell more rapidly. Consider 750 miles of the wire in one length, a galvanometer *a* being at the beginning of the wire, a second galvanometer *b* in the middle, and a third *c* at the end; these three galvanometers being in the room with the experimenter, and the third *c* perfectly connected with the earth. On bringing the pole of the battery into contact with the wire through the galvanometer *a*, that instrument was instantly affected; after a sensible time *b* was affected, and after a still longer time *c*: when the whole 1500 miles were included, it required two seconds for the electric stream to reach the last instrument. Again; all the instruments being deflected (of course not equally, because of the electric leakage along the line), if the battery were cut off at *a*, that instrument instantly fell to zero; but *b* did not fall until a little while after; and *c* only after a still longer interval,—a current flowing on to the end of the wire whilst there was none flowing in at the beginning. Again; by a short touch of the battery pole against *a*, it could be deflected and could fall back into its neutral condition before the electric power had reached *b*; which in its turn would be for an instant affected, and then left neutral before the power had reached *c*; a wave of force having been sent into the wire which gradually travelled along it, and made itself evident at successive intervals of time in different parts of the wire. It was even possible, by adjusted touches of the battery, to have two simultaneous waves in the wire following each other, so that at the same moment that *c* was affected by the first wave, *a* or *b* was affected by the second; and there is no doubt that by the multiplication of instruments and close attention, four or five waves might be obtained at once.

If after making and breaking battery contact at *a*, *a* be immediately connected with the earth, then additional interesting effects occur. Part of the electricity which is in the wire will return, and passing through *a* will deflect it in the reverse direction; so that currents will flow out of both extremities of the wire in opposite directions, whilst no current is going into it from any source. Or if *a* be quickly put to the battery and then to the earth, it will show a current first entering into the wire, and

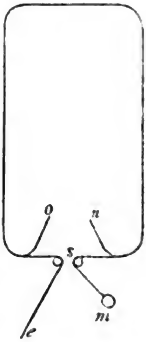
then returning out of the wire at the same place, no sensible part of it ever travelling on to *b* or *c*.

When an air wire of equal extent is experimented with in like manner, no such effects as these are perceived; or if, guided by principle, the arrangements are such as to be searching, they are perceived only in a very slight degree, and disappear in comparison with the former gross results. The effect at the end of the very long air wire (or *c*) is in the smallest degree behind the effect at galvanometer *a*; and the accumulation of a charge in the wire is not sensible.

All these results as to *time*, &c. evidently depend upon the same condition as that which produced the former effect of static charge, namely, *lateral induction;* and are necessary consequences of the principles of conduction, insulation and induction, three terms which in their meaning are inseparable from each other (Exp. Res. 1320, 1326,* 1338, 1561, &c.). If we put a plate of shell-lac upon a gold-leaf electrometer and a charged carrier (an insulated metal ball of two or three inches diameter) upon it, the electrometer is diverged; removing the carrier, this divergence instantly falls, this is *insulation* and *induction:* if we replace the shell-lac by metal, the carrier causes the leaves to diverge as before; but when removed, though after the shortest possible contact, the electroscope is left diverged,—this is *conduction.* If we employ a plate of spermaceti, instead of the metal, and repeat the experiment, we find the divergence partly falls and partly remains, because the spermaceti insulates and also conducts, doing both imperfectly: but the shell-lac also conducts, as is shown if time be allowed; and the metal also obstructs conduction, and therefore insulates, as is shown by simple arrangements. For if a copper wire, 74 feet in length, and $\frac{1}{12}$th of an inch in diameter, be insulated in the air, having its end *m* a metal ball; its end *e* connected with the earth, and the parts near *m* and *e* brought within half an inch of each other, as at *s*; then an ordinary Leyden jar being charged sufficiently, its outside connected with *e* and its inside with *m*, will give a charge to the wire, which

* 1326. All these considerations impress my mind strongly with the conviction, that insulation and ordinary conduction cannot be properly separated when we are examining into their nature; that is, into the general law or laws under which their phenomena are produced. They appear to me to consist in an action of contiguous particles, dependent on the forces developed in electrical excitement: these forces bring the particles into a state of tension or polarity, which constitutes both *induction* and *insulation;* and being in this state, the contiguous particles have a power or capability of communicating these forces, one to the other, by which they are lowered and discharge occurs. Every body appears to discharge (444, 987); but the possession of this capability in a *greater or smaller degree* in different bodies makes them better or worse conductors, worse or better insulators: and both *induction* and *conduction* appear to be the same in their principle and action (1320), except that in the latter an effect common to both is raised to the highest degree, whereas in the former it occurs in the best cases, in only an almost insensible quantity.

instead of travelling wholly through it, though it be so excellent a conductor, will pass in large proportion through the air at *s*, as a bright spark; for with such a length of wire, the resistance in it is accumulated until it becomes as much, or perhaps even more, than that of the air, for electricity of such high intensity.



Admitting that such and similar experiments show that conduction through a wire is preceded by the act of induction (1338), then all the phenomena presented by the submerged or subterranean wires are explained; and in their explanation confirm, as I think, the principles given. After Mr. Wheatstone had, in 1834, measured the velocity of a wave of electricity through a copper wire, and given it as 288.000 miles in a second, I said, in 1838, upon the strength of these principles (1333), "that the velocity of discharge through the *same wire* may be greatly varied, by attending to the circumstances which cause variations of discharge through spermaceti or sulphur. Thus, for instance, it must vary with the tension or intensity of the first urging force, which tension is charge and induction. So if the two ends of the wire in Professor Wheatstone's experiment were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction, after making the contact for discharge, might be in part removed from the internal portion of the wire at the first instant, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate that the middle spark would be more retarded than before; and if these two plates were the inner and outer coating of a large jar, or a Leyden battery, then the retardation of that spark would be still greater." Now this is precisely the case of the submerged or subterraneous wires, except that instead of carrying their surfaces towards the inducteous coatings (1483), the latter are brought near the former; in both cases the induction consequent upon charge, instead of being exerted almost entirely at the moment within the wire, is to a very large extent determined externally; and so the discharge or conduction being caused by a lower tension, therefore requires a longer time. Hence the reason why, with 1500 miles of subterraneous wire, the wave was two seconds in passing from end to end; whilst with the same length of air wire, the time was almost inappreciable.

With these lights it is interesting to look at the measured velocities of electricity in wires of metal, as given by different experimenters.

	Miles per second.
* Wheatstone, in 1834, with copper wire made it	288,000
* Walker, in America, with telegraph iron wire	18,780
* O'Mitchell, do. do. do.	28,524
* Fizeau and Gonnelle (copper wire) - -	112,680
* Do. (iron wire) - - -	62,600
† A. B. G. (copper) London and Brussels Telegraph	2,700
† Do. (copper) London and Edinburgh Telegraph	7,600

Here the difference in copper is seen by the first and sixth results to be above a hundred fold. It is further remarked in Liebig's report of Fizeau and Gonnelle's experiments, that the velocity is not proportional to the conductive capacity, and is independent of the thickness of the wire. All these circumstances and incompatibilities appear rapidly to vanish, as we recognize and take into consideration the lateral induction of the wire carrying the current. If the velocity of a brief electric discharge is to be ascertained in a given length of wire, the simple circumstances of the latter being twined round a frame in small space, or spread through the air through a large space, or adhering to walls, or lying on the ground, will make a difference in the results. And in regard to long circuits, such as those described, their conducting power cannot be understood whilst no reference is made to their lateral static induction, or to the conditions of intensity and quantity which then come into play; especially in the case of short or intermitting currents, for then static and dynamic are continually passing into each other.

It has already been said, that the conducting power of the air and water wires are alike for a constant current. This is in perfect accordance with the principles and with the definite character of the electric force, whether in the static, or current, or transition state. When a voltaic current of a certain intensity is sent into a long water wire, connected at the further extremity with the earth, part of the force is in the first instance occupied in raising a lateral induction round the wire, ultimately equal in intensity at the near end to the intensity of the battery stream, and decreasing gradually to the earth end, where it becomes nothing. Whilst this induction is rising, that within the wire amongst its particles is beneath what it would otherwise be; but as soon as the first has attained its maximum state, then that in the wire becomes proportionate to the battery intensity, and therefore equals that in the air wire, in which the same state is (because of the absence of lateral induction) almost instantly attained. Then of course they discharge alike, and therefore conduct alike.

A striking proof of the variation of the conduction of a wire by variation of its lateral static induction is given in the experi-

* Liebig and Kopp's Report, 1850 (translated), p. 168.
† Athenæum, January 14, 1854, p. 54.

ment proposed sixteen years ago (1333). If, using a constant charged jar, the interval *s*, page 90, be adjusted so that the spark shall freely pass there (though it would not if a little wider), whilst the short connecting wires *n* and *o* are insulated in the air, the experiment may be repeated twenty times without a single failure; but if after that, *n* and *o* be connected with the inside and outside of an insulated Leyden jar, as described, the spark will never pass across *s*, but all the charge will go round the whole of the long wire. Why is this? The quantity of electricity is the same, the wire is the same, its resistance is the same, and that of the air remains unaltered; but because the intensity is lowered, through the lateral induction momentarily allowed, it is never enough to strike across the air at *s*; and it is finally altogether occupied in the wire, which in a little longer time than before effects the whole discharge. M. Fizeau has applied the same expedient to the primary voltaic currents of Ruhmkorff's beautiful inducting apparatus with great advantage. He thereby reduces the intensity of these currents at the moment when it would be very disadvantageous, and gives us a very striking instance of the advantage of viewing static and dynamic phenomena as the result of the same laws.

Mr. Clarke arranged a Bain's printing telegraph with three pens, so that it gave beautiful illustrations and records of facts like those stated: the pens are iron wires, under which a band of paper imbued with ferro-prussiate of potassa passes at a regular rate by clock-work; and thus regular lines of prussian blue are produced whenever a current is transmitted, and the time of the current is recorded. In the case to be described, the three lines were side by side, and about 0·1 of an inch apart. The pen *m* belonged to a circuit of only a few feet of wire and a separate battery; it told whenever the contact key was put down by the finger; the pen *n* was at the earth end of the long air wire, and the pen *o* at the earth end of the long subterraneous wire; and by arrangement, the key could be made to throw the electricity of the chief battery into either of these wires, simultaneously with the passage of the short circuit current through pen *m*. When pens *m* and *n* were in action, the *m* record was a regular line of equal thickness, showing by its length the actual time during which the electricity flowed into the wires; and the *n* record was an equally regular line, parallel to, and of equal length with the former, but the least degree behind it; thus indicating that the long air wire conveyed its electric current almost instantaneously to the further end. But when pens *m* and *o* were in action, the *o* line did not begin until some time after the *m* line, and it continued after the *m* line had ceased, *i. e.* after the *o* battery was cut off. Furthermore, it was faint at first, grew up to a maximum of intensity, continued at that as long as battery con-

tact was continued, and then gradually diminished to nothing. Thus the record *o* showed that the wave of power took time in the water wire to reach the further extremity; by its first faintness, it showed that power was consumed in the exertion of lateral static induction along the wire; by the attainment of a maximum and the after equality, it showed when this induction had become proportionate to the intensity of the battery current; by its beginning to diminish, it showed when the battery current was cut off; and its prolongation and gradual diminution showed the time of the outflow of the static electricity laid up in the wire, and the consequent regular falling of the induction which had been as regularly raised.

With the pens *m* and *o*, the conversion of an intermitting into a continuous current could be beautifully shown; the earth wire, by the static induction which it permitted, acting in a manner analogous to the fly-wheel of a steam-engine or the air-spring of a pump. Thus, when the contact key was regularly but rapidly depressed and raised, the pen *m* made a series of short lines separated by intervals of equal length. After four or more of these had passed, then pen *o*, belonging to the subterraneous wire, began to make its mark, weak at first, then rising to a maximum, but always continuous. If the action of the contact key was less rapid, then alternate thickening and attenuations appeared in the *o* record; and if the introductions of the electric current at the one end of the earth wire were at still longer intervals, the records of action at the other end became entirely separated from each other; all showing most beautifully how the individual current or wave, once introduced into the wire, and never ceasing to go onward in its course, could be affected in its intensity, its time and other circumstances, by its partial occupation in static induction.

By other arrangements of the pens *n* and *o*, the near end of the subterraneous wire could be connected with the earth immediately after separation from the battery; and then the back flow of the electricity, and the time and manner thereof, were beautifully recorded; but I must refrain from detailing results which have already been described in principle.

Many variations of these experiments have been made and may be devised. Thus the ends of the insulated battery have been attached to the ends of the long subterraneous wire, and then the two halves of the wire have given back opposite return currents when connected with the earth. In such a case the wire is positive and negative at the two extremities, being permanently sustained by its length and the battery, in the same condition which is given to the short wire for a moment by the Leyden discharge (p. 90); or, for an extreme but like case, to a filament of shell-lac having its extremities charged positive and negative.

Coulomb pointed out the difference of long and short as to the insulating or conducting power of such filaments, and like difference occurs with long and short metal wires.

The character of the phenomena described in this report induces me to refer to the terms *intensity* and *quantity* as applied to electricity, terms which I have had so frequent occasion to employ. These terms, or equivalents for them, cannot be dispensed with by those who study both the static and the dynamic relations of electricity; every current where there is resistance has the static element and induction involved in it, whilst every case of insulation has more or less of the dynamic element and conduction; and we have seen that with the same voltaic source, the same current in the same length of the same wire gives a different result as the intensity is made to vary, with variations of the induction around the wire. The idea of intensity, or the power of overcoming resistance, is as necessary to that of electricity, either static or current, as the idea of pressure is to steam in a boiler, or to air passing through apertures or tubes; and we must have language competent to express these conditions and these ideas. Furthermore, I have never found either of these terms lead to any mistakes regarding electrical action, or give rise to any false view of the character of electricity or its unity. I can not find other terms of equally useful significance with these; or any, which, conveying the same ideas, are not liable to such misuse as these may be subject to. It would be affectation, therefore, in me to search about for other words; and besides that, the present subject has shown me more than ever their great value and peculiar advantage in electrical language.

Note.—The fuse referred to in page 86 is of the following nature:—Some copper wire was covered with sulphuretted gutta percha; after some months it was found that a film of sulphuret of copper was formed between the metal and the envelope; and further that when half the gutta percha was cut away in any place, and then the copper wire removed for about a quarter of an inch, so as to remain connected only by the film of sulphuret adhering to the remaining gutta percha, an intensity battery could cause this sulphuret to enter into vivid ignition, and fire gunpowder with the utmost ease. The experiment was shown in the lecture-room, of firing gunpowder at the end of eight miles of single wire. Mr. Faraday reported that he had seen it fired through 100 miles of covered wire immersed in the canal by the use of this fuse.

Art. XIV.—*Reclamation of Borocalcite, as distinct from a mixture of minerals, found near Iquique, South Peru;* by Aug. A. Hayes, M.D., Assayer to the State of Massachusetts.

This mineral which was early analyzed and described by myself, has under the name of Teza, been confounded by Messrs. Ulex and Lecanu with other minerals which occur with it in the same bed. These chemists have apparently analyzed the minerals, constituting distinct species, together, without that careful separation mechanically, which should always precede a chemical analysis.

The parcel I originally received from John H. Blake, Esq., weighed several hundred pounds, and the existence of other salts with the borocalcite, was pointed out by me in detail. Yet, there were nodular masses frequently found, containing mere traces of other compounds, and quite as pure as commercial salts in general.

Supposing that future explorations had shown a more intimate union of the different salts, I have refrained from noticing the discordant results obtained by others, until the mineral as an article of commercial importance, should come to my hands.

Within a few weeks, the "muster" samples of two hundred tons have been sent to me, and I give the results obtained by careful analysis of these, as follows:

Water of crystallization,	27·16
Anhydrous borate of lime,	41·34
Glauberite,	23·20
Chlorid of sodium,	6·40
Sand,	1·90
	100·00

Some samples could be differently reported, but the point which I deemed essential, after reading the statement of M. Lecanu was, the absolute proof obtained by different modes of analysis, of the *entire absence of any borate of soda*, in the samples. The Glauberite and common salt are mere mixtures, apparent on inspection, and most easily separable by washing,—the borate of lime in the form of silky fibres being suspended in the water, and when collected and analyzed, giving the same proportions of acid and base, as the salt artificially formed.

As a source of boracic acid, in the manufacture of borax, I have already called public attention to this mineral, and it is now seeking the markets of the world, in large quantities.

16 Boylston St., Boston, 3d Apr. 1854.

ART. XV.—*On the present condition of the Crater of Kilauea, Hawaii;* by Rev. TITUS COAN.*

KILAUEA is still quiet. Many parties have visited the crater during the past year, and of these I have made special inquiries, as I have not been able to visit it myself. Changes have been slowly taking place within the crater. The aperture in the summit of the great dome which covers the igneous lake,† is gradually enlarging by the falling of avalanches from its walls, and thus revealing more and more of the fiery abyss below. But the melted lava does not approach the top of the dome. It is still 150 feet below, and you see it as you see the fire in the bottom of a coal-pit, by looking down through an orifice in the summit. The dome is probably two miles in circuit at its base, and some 400 feet high. Steam and smoke are constantly escaping from numerous holes and fissures in the dome, and the whole resembles a vast coal-kiln in the process of charring. On the western side of the dome a large fissure has been opened from the base to near the rim of the orifice at the summit, and from this rent, near the base, streams of lava have been occasionally poured out, inundating the area around the dome. This lateral outlet has prevented the lake from rising and flowing off at the summit orifice. Several other small lakes have been opened and closed at different points in the crater during the past year. These have varied from one-fourth of an acre to two acres in area, and their action has varied in intensity. A number of cones have also been thrown up in different parts of the crater, and there are evidences of partial overflowings in many places over the bottom of Kilauea. But these changes have occurred when no one was present to witness them.

A gradual rising is going on in the whole floor of the crater. This is effected by two causes—first, by the lifting forces below, as gases, igneous fusion, etc., and second, by eruptive overflowings: the former is more uniform and general—the latter irregular and partial. Every thing is silently preparing for another grand eruption; but when this will occur, at what point, under what circumstances, and with what effects, no one can tell.

You are aware that all the central part of the floor of the crater, embracing nearly one half of its area, is an elevated plateau, the highest points of which are now some 600 feet above what was the floor after the eruption of 1840. This central elevation rises in some places gradually, in others abruptly, from the surrounding floor. On the east and southeast its mural walls are perpendicular, presenting a dark, lofty, and frowning rampart,

* From a letter to J. D. Dana, dated Hilo, Hawaii, Jan. 30, 1854.

† The lake referred to occupies the southern end of the large area that forms the bottom of the crater of Kilauea.—D.

which no human foot can scale. At some points, immense avalanches have fallen from these high battlements, forming a steep inclined plane of confused and toppling debris, from the base of the walls two-thirds of the way up to their summits. On the north and west the elevation is less and less abrupt, and the plateau can be ascended from these points.

This central "table-rock," as will be seen, is surrounded by what used to be called "The Black Ledge," embracing all that portion of the crater which was sunk to the depth of 400 feet during the eruption of 1840. Of course "the Black Ledge" is now a lower plane than this central table, at its highest points, by about 200 feet. Many parts of "the Black Ledge," have also been elevated by local overflowings, and all of it, probably, by subterranean forces.

Occasionally the light of Kilauea is seen along the shores of Hawaii; but these exhibitions have been faint and few since 1840—a result of the roofing over of Halemaumau (the great lake). It may be doubted whether Kilauea will ever again assume its former activity and grandeur. From repeated agitations of the sea around our shores,—instances of which have recently occurred—we are led to think that submarine eruptions are occasionally taking place on the submerged portions of Hawaii, or from volcanic mountains and cones covered by the waters of the Pacific. These hidden eruptions will, doubtless, add to the dry land in our ocean in due time. Should there be a connection and a sympathy between these lower eruptive points and those above us, we may argue a diminution of the upper fires in proportion to the intensity of the submarine; and yet this may not follow, as we have magnificent eruptions on Mauna Loa, while Kilauea sleeps. These phenomena have puzzled me; but the solution you have given in your admirable work on geology satisfies my mind better than any theory I have seen.

All is quiet at Mauna Loa. The eruption of 1852 still steams a little at a few points in the woods back of us, not half so much however, as the eruption of 1840. There are points on this line, (that of 1840,) midway from Kilauea to the sea, where there are still much smoke and heat.

You ask if there were any small cones thrown up along the stream in the eruption of 1852. There were a few, but none of much size, so far as I explored. You are aware that the eruption commenced on the 17th of February, on the summit of Mauna Loa. In two days this valve closed, and the summit action ceased. On the 20th the lateral valve opened, 4000 feet below the top of the mountain, and the thundering torrent of fire rushed out and continued its awful disgorgement for twenty days. Between the summit point and the lower one, the ribs of the moun-

tain were rent, and seams and fissures were opened by the expansive force of the internal fire, as it forced its way in subterranean chambers down the sides of the mountain to the point of final eruption. Along the line of this covered duct an occasional jet was thrown up through a fissure to the surface, and in some places small cones were raised like warts on the side of the mountain. Many such were formed by the grand eruption of 1843, an account of which you have probably seen,—and the exploration of which was one of the most arduous and perilous I have ever undertaken. You will recollect that this eruption, (1843,) when it had flowed down the northern surface of the mountain for some two weeks, extending about thirty miles in length, with a breadth of from one to three miles, suddenly solidified on its surface, like a frozen river, still continuing its flow for weeks in a subterranean canal from the top of Mauna Loa to the base of Mauna Kea, throwing off lateral streams to the west and northwest. On this stream cones were thrown up from thirty to seventy feet high, usually with an orifice in the top, down which you could look and see the noiseless river of igneous rock, fused to whiteness, and gliding under your feet at the rate of a steam ship.

Art. XVI.—*Note on the genus Buckleya*; by Asa Gray, M.D.

In a foot-note on page 170 of the 45th volume of this Journal (eleven years ago) is published a brief character of an interesting Santalaceous genus, founded on the *Borya distichophylla* of Nuttall, and named *Buckleya* by Dr. Torrey, in compliment to Mr. S. B. Buckley, who first collected and communicated specimens with the fructification. Although specimens were collected about the same time by Mr. Rugel, and doubtless distributed in Europe, as were fruiting specimens gathered by Mr. Sullivant and myself in the autumn of 1843, I am not aware that the genus has been mentioned in any botanical work, or that any further knowledge has been gained respecting it, except the little which I have now to communicate.

In the year 1843, I was fortunate enough to procure and transport to Cambridge several living plants. Some of them were immediately sent to the Royal Botanic Gardens at Kew; but they probably perished in the voyage. Of those retained only one survived in our botanic garden; where it is perfectly hardy, and forms a shrub of 6 or 7 feet in height, remarkable for its neat habit, slender green boughs, and pretty distichous leaves. It proved to be a female plant; and has flowered and produced abortive fruit for the last two or three years, in the form of a fusiform pericarp, crowned with four elongated and foliaceous calycine lobes. But the greenish flowers, although not very small,

are so inconspicuous that they have until now escaped my notice at the proper season for examining them.

The point of principal consequence is that the female flowers prove to have a *double perigonium;* one, moreover, in which the exterior or "accessory calyculus," far from being minute or rudimentary, is much more conspicuous than the inner, being of more than twice its length! The divisions of this accessory perigonium are regularly alternate with the inner or normal perigonium of the family, that which is opposed to the stamens, and which manifestly answers to the single floral envelope in the allied *Pyrularia.* But they so perfectly resemble the leaves in shape and texture, (although narrower as well as smaller,) as also in vernation, expanding with the leaves some days before the inner perigonium opens, that they do not perhaps suggest much argument, in addition to what is already furnished by *Olacineæ* and *Loranthus*, for changing the generally received view of the nature of the floral covering in *Santalaceæ.* Their foliaceous nature is further evinced by their distinct articulation with the summit of the calyx-tube. These long and narrow lobes are the "perigonium" of Dr. Torrey's character of the genus, at least of the female flowers; the proper perigonium having probably fallen in the specimens he examined, although it is by no means very deciduous. I have not seen the male flowers.

A second peculiarity of *Buckleya* relates to the æstivation of the inner or proper floral envelope; which is not valvate, as in all other known Santalaceous genera, but *imbricative,* decidedly, though not very strongly so.

A third but slighter discrepancy from the general character of the *Santalaceæ*, as commonly stated, is found in the opposite or sub-opposite leaves. These are said, in the published character of Buckleya, to be alternate: but they are placed, for the most part, in pairs on the slender branchlets, the whole much resembling the leaflets of a pinnate leaf, and the two leaves of each pair are either somewhat disjoined, or as frequently exactly opposite, at least on the upper part of the branchlets. The leaves are more strictly opposite in *Darbya*, *Fusanus*, and *Santalum* itself.

It might be urged, apparently on very strong grounds, that a plant whose floral envelopes (at least in the male flowers) are distinctly double, and the inner series imbricated in æstivation, cannot belong to the order *Santalaceæ;* the more so as it is said in the published character to have a uniovulate ovary. This character, however, may have been merely inferred from the solitary seed, or *fertilized* ovule; and it is evident from the absence of the inner perigonium that the female flowers examined were in an advanced state. A dissection of the unimpregnated flowers in the living plant brings to view in *Buckleya* the ordinary struc-

ture of the Santalaceous ovarium. The small cell, if it may be so called, where there is no empty cavity, is filled by a short, oval or olong, erect central column, which bears near its free apex four very minute and simple ovules, evidently reduced to naked nuclei. This genus therefore undoubtedly belongs to the small alliance or class that comprises the *Olacineæ* and the *Santalaceæ;* and as respects these two orders I should not hesitate to refer it to the latter, notwithstanding the double floral envelopes. The moderate imbrication of the divisions of the perigonium in the bud is surely a discrepancy of slight importance in comparison with this characteristic ovulation; and I cannot but recognize in this case something like a direct confirmation of the opinion I had already ventured to express (Botany of the U. S. Expl. Exped. i, p. 301), namely, that Mr. Miers, in excluding on such grounds *Bursinopetalum* and *Pleuropetalon* from his order *Icacineæ*, has over-estimated the importance of a character which, however valuable, is seldom perfectly stable throughout all the members of a natural order.

As respects the female flowers of *Buckleya*, it therefore appears that the published character should be modified as follows:

Fl. fœm.; Perigonium basi quadribracteolatum; tubo clavato cum ovario connato; limbo duplici, utroque quadrisecto, laciniis exterioris (calyculi accessorii) linearibus foliaceis tubo sublongioribus diu persistentibus, interioris triangulari-ovatis æstivatione modice imbricatis exterioribus plus dimidio brevioribus deciduis. Discus epigynus planus, quadrangulatus, angulis parum liberis perigonii interioris laciniis alternantibus. Stamina nulla. Stylus breviusculus: stigma cruciato-quadrilobum, lobis perigonii interioris laciniis oppositis. Ovarium uniloculare. Ovula 3 vel 4, minima, simplicissima, ex apice placentæ centralis crassæ liberæ (loculum parvum implentis) pendula.

Art. XVII.—*On a mode of giving permanent flexibility to brittle specimens in Botany and Zoology;* by Prof. J. W. Bailey, U. S. Military Academy, West Point, N. Y.

The excessive fragility in the dry state, of many plants, and particularly of those which secrete carbonate of lime is well known to botanists. There is no herbarium in existence in which the specimens of Amphiroa, Jania, Corallina, Halimeda, Liagora, Chara, &c. are not in a more or less mutilated condition, which becomes worse every time the plants are examined. In studying a large collection of the stony Algæ I was led to remark their perfect flexibility while moist, which passed to great brittleness when dry, and it occurred to me that if they could be kept permanently moist they would remain permanently flexible.

I then remembered that General Totten, of the U. S. Engineers, had mentioned to me, some years ago, his success in preventing the cracking and peeling off of the epidermis of various shells, by impregnating them with chlorid of calcium. I also remembered Boucherie's experiments with the same substance in giving flexibility to wood. The principle that *a substance which is flexible when moist, will remain permanently moist, and therefore permanently flexible, when impregnated with a deliquescent salt*, is so obviously true that it needed no experiments to convince me of its applicability to the fragile plants above mentioned, and to many other specimens in natural history. But as practical difficulties often occur in the application of correct principles, I have tested the process by numerous experiments in which chlorid of calcium was employed to give flexibility to various vegetable and animal products, and the results have fully equalled my expectations. My specimens of Amphiroa, Jania, Corallina, &c. after being impregnated with this salt, and then exposed for months to the air, can be handled as freely as if just taken from the water, and they permanently retain almost the utmost degree of pliability they are capable of receiving. Species of dry, crisp and brittle Lichens when treated in the same way became soft, elastic, and flexible, so as to bear very rough handling with perfect impunity. Many of the common Algæ which shrink much in drying, and therefore assume a very unnatural appearance, and besides are apt either to become cracked or torn, or to wrinkle up the paper to which they adhere, retain after immersion in this salt, nearly their normal degree of distention, and preserve a much more natural appearance than when dried in the usual way. Many dried specimens of plants whose leaves, flowers or fruit, drop off almost at a touch from specimens in my herbarium, became permanently pliable when immersed for a short time in a solution of chlorid of calcium, and could then at any time be handled freely, while their appearance was in no degree injured.

In the animal kingdom, the results obtained in restoring permanent flexibility to dry and brittle specimens of Crustaceans, Insects, Gorgonias, Sponges, &c. were equally satisfactory, and have convinced me that almost every naturalist will, in his own department, find many useful applications for this process.

The *mode of application* which I have employed is to immerse the dry specimen for some time in a neutral saturated solution of chlorid of calcium, (which any one can make for himself by saturating chloro-hydric acid with marble,) and then after the specimen has become sufficiently softened to bend easily, remove it and let it drain in the open air. In some cases where the specimens do not imbibe the salt readily, it is well to soften them in warm water before immersion in the salt. A speedy impregnation will then take place, after which the specimens, if plants,

may be subjected to moderate pressure in the usual way, and restored to the herbarium, while other specimens may be kept on shelves or in any way usually employed for similar objects, and all will for any length of time retain sufficient moisture to prevent brittleness. The salt being neutral, no fear need be apprehended of its injuring color or texture, while its antiseptic properties will aid in the preservation of matters liable to decay.

Art. XVIII.—*Caricography;* by Prof. C. Dewey.

(Continued from vol. ix, p. 30, Second Series.)

No. 243. *Carex aristata*, R. Br., var. *longo-lanceata*, Dew.

Pistillate scale oblong, long-awned or long-cuspidate, longer than the fruit; leaves, sheaths, and bracts scabro-pubescent.

Collected in the Mauvaises Terres (Bad Lands) of Nebraska Territory in 1853 by F. V. Hayden.

The common forms of C. aristata, R. Br. and of C. trichocarpa, Muh., appear abundant over that western country, with some tendency to unusual length of their scales, but in the above marked variety the scales are considerably longer than the fruit, and sometimes only very elongated lanceolate. Perhaps this plant should be held to be a distinct species,

No. 244. *C. nebrascencis*, Dew.

Spicis 4–6; staminiferis binis apicem approximatis oblongis brevibus densis, inferiore sessili parva, cum squamis oblongis subobtusis; pistilliferis 2–4, oblongis brevi-cylindraceis densifloris, superioribus apice staminiferis sessilibus, inferiore brevi-pedunculata; bracteis lanceolatis sessilibus culmum æquantibus; fructibus *distigmaticis* convexis obovatis vel ellipticis basin teretibus brevi-apiculatis ore sub-bilobis, squama ovata acuta vel lanceolata paulo brevioribus: culmo acute triquetro lævi basin foliato.

Culm 1-2 feet high, usually 16–20 inches, sharp-triquetrous, smooth, scarcely rough between the spikes, with lanceolate leaves towards the base shorter than the culm and soft, glabrous, serrulate on the edges, and with sessile bracts under the spikes as long as or longer than the culm above; staminate spikes two, oblong, close-flowered, short, lower one very short and sessile, with oblong and acutish scales: pistillate spikes 2–4, usually three, short, oblong, thick, erect, rarely an inch long, cylindric, densely flowered, sub-approximate, two upper sessile and often staminate at the apex, the lowest short pedunculate; stigmas two; fruit elliptic or obovate, slightly tapering at the base, short rostrate or round-apiculate, entire or sub-bilobed at the orifice, glabrous and double

convex; pistillate scale ovate, acute, or mucronate, sometimes lanceolate, narrower and once and a half longer than the fruit, tawny with a white line on the back.

No. 245. *C. Haydenii*, Dew.

Spicis 4–6, cylindraceis tenuibus; interdum quatuor, suprema staminifera, reliquis fructiferis; nunc staminifera unica vel binis, inferiore basin fructifera: pistilliferis 3–5, distigmaticis longo-cylindraceis erectis gracilibus laxifloris subremotis foliato-bracteatis, superiore vel pluribus apice staminifera, et infima brevi-pedunculata basin rariflora; fructibus ellipticis utrinque convexis apiculatis ore integris lævibus, squama lanceolata nigrescente dorso alba sub duplo brevioribus; culmo triquetro lævi basin foliaceo apicem scabro 2–3 pedali.

Culm triquetrous, erect, 2–3 feet high, smooth, scabrous above, leafy towards the base; spikes 4–6, cylindric, slender, erect; sometimes four, one staminate, and others nearly destitute of fruit; sometimes two staminate, the lower with fruit at the base, and four pistillate with the upper staminate at the apex, all long cylindric, 2–4 inches long, slender, erect, loose-flowered, leafy-bracteate, the lowest short-pedunculate and quite loose-flowered at the base; stigmas two; fruit oval or obovate, tapering at base, convex on both sides, short-rostrate or apiculate, entire at the orifice, smooth, often dark brown or nearly black in maturity; pistillate scale lanceolate, blackish with a white dorsal line, and nearly twice the length of the fruit.

On Missouri River near Fort Pierre; collected by Ferdinand V. Hayden in 1853, among the 1200 species of plants obtained while collecting fossils, &c. for Prof. James Hall, State Geologist, Albany. With the preceding three species of Carex were many others, all of which Prof. Hall politely put into my hands for examination.

Note.—The following species, just alluded to, were also collected by Dr. Hayden in that western region: C. eburnea, Boott; C. Meadii, Dew.; C. lanuginosa, Mx.; C. aristata, R. Br.; C. lacustris, Willd.; C. riparia, Good.; C. Shortii, Torr.; C. Muhlenbergii, Schk.; C. rosea, Schk. and its var. radiata, Dew., which was figured by Kunze for C. disperma, Dew., and was a great mistake; C. anceps, Muh.; C. straminea, Wahl.; C. Steudelii, Kth.; C. trichocarpa, Muh.; C. vesicaria, L.; C. festucacea, Schk.; C. grisea, Wahl.; C. stricta, Lam.; C. strictior, Dew.; C. mirabilis, Dew.; C. leporina, L., credited before by Boott to Arctic America; C. stenophylla, Wahl., found also by Dr. Richardson at Carlton House, and on Rocky Mountains, and abundant in Nebraska Ter.; C. marginata, Muh., exactly the form figured by Schk. in his fig. 143, and from which C. pennsylvanica, Lam. differs in its fruit and leaves; C. vulpinoidea, Mx.; C. stipata,

Muh.; C. vulpina, L., so exactly the European plant, that there can be no doubt of its correct determination in Ohio, and that the hesitation expressed by Dr. Boott in Richardson's Arctic Expedition, p. 466, is groundless, especially from any supposed resemblance to C. stipata, Muh., as the two are vastly different; C. Davisii, Tor.; C. longirostris, Tor.; and C. recta, Boott.

Art. XIX.—*Reviews and Records in Anatomy and Physiology;* by Waldo I. Burnett, M.D., Boston.

I. Psorospermia.*

Lieberkühn has furnished a communication of considerable length and detail on this subject, to which we refer particularly from its interesting relations. As a key to the article we may give his conclusions, as follows:

"The kidneys of some frogs contain cysts which enclose contents of very manifold characters, namely: 1. A peculiar, uniformly divided, granular mass. 2. This mass encompassed by small groups of an oval or fusiform shape. 3. Fusiform bodies, invested with a structureless membrane. 4. Developed psorospermatic corpuscles. These different objects are found wholly or partially in one and the same cyst. The mature psorospermial corpuscles usually contain three to five baton-like or ellipsoid or globular diaphanous corpuscles which are structureless; they usually have also a rather large nucleus. The diaphanous corpuscles are seen moving and springing in their capsules, and the nucleus is thereby moved about hither and thither. Such kidneys contain also free amœba-like corpuscles, and gregarina-like bodies largely nucleated."

These formations are by no means common,—our author having found them in four cases only out of a thousand specimens he has examined.

But in other animals, and in other organs he has found similar formations, as have others, such as Müller, Gluge, Leydig, before him. In fact, these psorospermial forms occur in both a free and a cystic state in different tissues.

The question is certainly a most interesting one: What signification shall be put upon these singular animal-like forms? But this is only one passage in the comprehensive question, What are most infusorial forms not evidently of a vegetable nature which every microscopist meets with perhaps daily in his studies? The subject certainly is not yet ripe for decision, but we may allude to it in a suggestive point of view. Both Kauffmann and Lieberkühn, in watching these Psorospermia in glasses on their tables,

* *N. Lieberkühn.* Ueber die Psorospermien, in *Müller's* Arch., 1854, Hft. 1, p. 1–25.

have observed that they multiply by a segmentation of their nucleus, and that the product of this division resembles precisely the parent. In some specimens observed by Lieberkühn, taken from a dog, he found the parent vesicle to contain sometimes 16 segmented globules. But here the observations unfortunately ceased, and we are not aware that in any case or instance they have been extended beyond this point; that is, so as to show that the offspring of this segmentation which so closely resembles its parent pursues the same course and produces by segmentation a third series. The doctrine that individual animal forms may be unicellular or that an animal may be composed solely of a single cell, as advanced by Siebold and Kölliker,* we regard as wholly untenable in the present state of science; for, aside from its being against the general analogy of individual zoological forms, it has not yet facts enough to sustain it merely as a point of observation. The cell is indeed typically the primordium of all organized forms, but true individual animal life seems to involve a cycle of relations not implied in single cells; in other words, these last must always lose their character as such in a definite form which belongs to the individual. Extended researches in Microscopy in all directions of the organic world,—all tend to establish the doctrine that sex lies behind all true individual forms,—that the ovum is the point of departure on one side, and the spermatic particle on the other,—and that by the conjunction of the two a new individuality is produced. There is indeed a most striking and beautiful uniformity between the simple cell and the ovum in a morphological point of view, or between the cell and the parent sperm-vesicle, thereby indicating a unity of idea and place in the first expression of life and the functional means of its cycle of actions; but without wishing to be mystical, it appears to us that life as expressed under the individual whether in its first or last forms,—as an egg ready to develope, or as a complete animal, rises high above and implies a great deal more than simple cell-conditions. We argue, then, that all true animals arise primarily or secondarily from ova, and therefore have sex, and that those animal-like forms so often seen as parasites or entozoa in animals must for the present stand undetermined, or if any interpretation is to be put upon them, they may be regarded as undeveloped forms of true animals, passing through various metamorphotic changes to which we have some clew in the remarkable phenomena of *alternation of generations.*

If the contents of the lower portion of the intestine of a frog be examined under the microscope, there will usually be found innumerable moving particles which give a very life-like aspect to the whole field. These belong to the infusorial genus *Bodo* of

* *Siebold* and *Kölliker.* See their Zeitsch. für wissenschaftliche Zoologie, I, p. 270, and ibid p. 1.

Ehrenberg. Examined with the highest and best microscopic powers, they are found to be composed of a more or less globular head to which is attached a thread-like tail of considerable length. This head taken by itself has all the appearances of a simple cell,—it is nucleated and even nucleolated; yet the whole body moves about by means of its tail in a most animal-like manner and in studying the field one can hardly divest the mind from the opinion that they are true animals.

The intestinal canal of many insects likewise, especially those feeding in damp, moist places, will often be found teeming with forms so large and numerous that it is singular that the insect should live. Many of these forms are composed of a more or less globular sac filled with a punctiform matter in which lies a round nucleus; at one extremity of this sac is an orifice surrounded by a circle of cilia. Others are more vermiform, regularly wrinkled, but apparently non-nucleated. These belong to the Gregarinæ, and are the forms upon which Siebold and Kölliker have based their doctrine of unicellular animals. Other instances might be cited, equally prominent, which almost daily come under the eye of the microscopist in his studies in the lower department of the animal kingdom.

Our own observations upon these objects have not led us to the view that they are, any of them, perfect individual forms;* on the other hand, research is constantly reducing their generic numbers, on the one side, by showing that many so-called genera are only different developments of one and the same form; and by removing them, on the other, from that *Receptaculum omnium animalium et plantarum*—the Infusoria—it being shown that they are only germs or larval forms of some of the inferior classes.† The recent investigations of Siebold and others, in Helminthology, to which we shall soon allude, have shown how varied may be the larval forms, how dissimilar from the true adult animal, and how remarkable the localities in which they occur, in the case of many of the Entozoa. In the case of the Psorospermia, or the Gregarinæ, or other forms which have been grouped under special genera or species, we must wait further research, and they will then, we think, be shown to be undeveloped forms. As to the question of the animal or vegetable nature of such organisms, it seems equally obscure, for the older criteria by which animals were separated from plants have long since been regarded as invalid; and some of those which in late years have been regarded as among the most constant, have quite recently been declared equally unsound.

* For *Bodo*, see Boston Journal of Natural History, vi, No. 3, 1853, p. 312.

† Thus *Agassiz* has shown that *Paramæcium* and *Bursaria*, &c. are only larval forms of Planariæ. See Annals of Nat. Hist., vi, 1850, p. 156. *Euglena*, *Amœba*, and others, will most probably meet with a like resolution.

Robin has argued that the Psorospermia are plants because they contain cellulose; but as the investigations of Kölliker, and of Löwig and Schacht have shown that this substance occurs indubitably in animal tissues, this can no longer be considered as a criterion.* We are reduced to *voluntary motion* as the only now known differential criterion on this subject, and as this must be a point on which different observers will vary, the subject must still remain unsettled; but we protest against any fusion of the two organic kingdoms on this obscure arena.

II. On the Mermithes.†

A memoir of great worth has recently appeared upon these singular parasites, which has a double importance of quite clearing up the history of these animals in all their stages, and of furnishing a contribution to the histology of the lower animals of a most valuable character. This memoir is by G. Meissner of München, under the direction of Siebold who furnished him with specimens and other opportunities for its successful prosecution. Seldom have we met with a paper of more careful and extended detail, and which leaves so little behind for investigators in the same direction. Added to this textual detail, each and every anatomical point is illustrated by admirably executed figures. With our limited space we can at best notice only a few of the more prominent points of this paper.

In the first place it should be remarked that the natural history of the Gordiacei was for a long time quite obscure and little understood, and many detached observations not of a parallel character did not improve the subject. To the sagacity of Siebold we are indebted for the successful resolution of the whole enigma, and the results he has obtained are as singular as new.‡ It appears that these animals live part of their life as a regular entozoon, and the rest as an independent being. And what is most remarkable, they enter the animals in which they are for a time parasites, not in the form of eggs, as do other Helminths, but as more or less developed forms. The animals in which they live as parasites are almost exclusively Insects of different orders in both the larva and imago state. In the abdominal cavity of the larvæ of *Yponomeuta albicans*, Siebold found numerous undeveloped forms of *Mermis albicans*. Watching them he found that after further growth, they perforated the skin of these larvæ and

* For full reference to the subject of cellulose in the tissues of the lower animals, see *Siebold* and *Stannius's* Comparative Anatomy, Amer. ed., vol. i, § 172.

† Beiträge zur Anatomie und Physiologie von Mermis albicans. Von Dr. *Georg Meissner*. In *Siebold* and *Kölliker's* Zeitschrift für wissenschaftliche Zoologie, v, 1853, p. 207–285.

‡ *Siebold*. See the Entomol. Zeitung zu Stettin, 1848, p. 292, 1850, p 329, also Beiträge zur Naturgeschichte der Mermithen, in *Siebold* and *Kölliker's* Zeitsch. für wissensch. Zool., v, 1853, p. 211.

made their escape. These freshly-escaped individuals were all sexless, but contained each a considerable *corpus adiposum*, at the expense of which their sexual parts were subsequently developed. These animals crawled about, and soon entered some damp earth, where they remained several months, during which time they were further developed, changed their skin, copulated and laid their eggs. The embryos hatched from these eggs, had the filamentoid form of the adults, and as Siebold conjectured that they intended to come to the surface for the sake of entering in their turn young insects, he procured quite young larvæ of this same insect and put them in an hour-glass together with the young Mermithes. In a few hours they had entered the body of these larvæ, two or three in each. Siebold had the precaution to make this point certain by carefully examining these larvæ previously and determining that their bodies were free of these parasites. After this, the same round of life is again passed. It would appear, then, that these animals pass their earlier (but not their embyonic) conditions of life whereby they attain their development—in fact a proper larval state—in the bodies of insects, and that their life as distinct sexed individuals is free and non-parasitic. Siebold found this species in very many genera of Lepidoptera, also in different species of Orthoptera, Coleoptera, and Diptera. We may mention that the common cricket as also some other Orthoptera, are frequent recipients of *Mermis*, and we have seen many specimens of this kind. Until Siebold's recent contributions we had supposed in common with other naturalists, that these Helminths merely hibernated in these insects, but this is now quite improbable.

So much for a brief reference to the mode of life of these animals; we will now turn and glance at some of the important histological points as wrought out by Meissner.

Cutaneous System.—Omitting the very full details given of the structure of the skin in these animals, its composition of three distinct layers, &c., we will allude only to the fact that *Chitine* enters likewise into its formation. This fact is important as corroborative of other observations. Chitine was formerly supposed to belong exclusively to the teguments of the Arthropoda, being particularly prominent in the skin of insects; but recent chemical analyses of the teguments of lower animals show that it occurs in nearly every class of the Invertebrata.* It can therefore no longer be regarded as having diagnostic characteristics for certain classes, but sustains relations to the external dermic skeleton of the Invertebrata generally, analogous to those of bone in the four classes of Vertebrata.

* Besides the present case we would refer to the following: *Grube*, *Müller's* Arch. 1848, p. 461, and *Wiegmann's* Arch. 1850, p. 253; *Schultze*, Beitr. zur Naturgesch. d. Turbellarien, p. 33; and *Leuckart* in *Siebold* and *Kölliker's* Zeitsch., 1851, p. 192, and *Wiegmann's* Arch. 1852, p. 22.

Muscular System.—This was found quite developed, and it is a singular fact that all the muscles have a longitudinal direction. Transverse muscles do not exist. But Meissner has indicated a histological feature of muscular tissue in these animals, which deserves notice. It is well known that striated muscular fibre is rather limited in its distribution among the Invertebrata. As stated in another place,* we have not observed it below the Articulata, and have regarded it as actually absent in the remaining classes —the Cephalopoda, Cephalophora, Acephala, Annelides, Turbellaria, Helminthes, Echinodermata, Acalephæ and Polypi. Now, we have hitherto supposed from observation that the fibre being the true embryological element of muscle, a further division into fibrillæ occurred only in the higher form of this fibre, the so-called *striated* muscle; in other words, that a fibrillated structure of muscular fibre was found only in the striated form. But Meissner describes the fibre of *Mermis* as readily capable of being split up into longitudinal fibrillæ of the most regular and delicate character, and yet neither these fibres nor fibrillæ are properly transversely striated. He remarks however, that an appearance like striation is sometimes observed by a wave-like contraction of the fibre.† Results of this character which the more careful research of the present day is developing, in studies of the lower animals especially, fully indicate that the subject of muscular tissue is not well understood as to its manifold variations of form; at least, after we have left the typical forms of the higher animals. Thus, as company for the present instance, I may mention that Leydig‡ found the muscles of the alimentary canal of *Artemia* among the Crustacea, composed of spindle-shaped instead of disc-like elements, so arranged, points and bases alternating, as to form a symmetrical fibrilla. In conclusion upon this system, we may remark that Meissner found here no sarcolemma, and no perimysium of the muscular layer.

Nervous System.—The researches of this investigator in this direction have particular interest, because this system has been generally denied to the Gordiacei, and if seen by previous observers it was only most unsatisfactory.§ But the histology of this system is quite as interesting.

Meissner found it so developed that he divides it into three portions: a central, a peripheric, and a splanchnic portion.

* This Journal, Jan. No., 1854, p. 89.

† We suspect it is this same wave-like aspect that has been often mistaken for striation in the muscles of some of the lowest animals, thereby leading to no little discrepancy among observers in their statements. See this Journal, Jan. No., 1854, p. 92, notes.

‡ *Leydig.* Ueber Artemia salina und Branchipus stagnalis, in *Siebold* and *Kölliker's* Zeitsch., iii, p. 280, Taf. viii, fig. 6.

§ *Berthold* and *Blanchard* both supposed they saw cords which might be nerves, but their observations were wholly unsatisfactory;—for references see *Siebold* and *Stannius'* Comp. Anat., Amer. ed., vol. i, § 104, note 5.

The *central portion* is divided into two parts, one at the cephalic, the other at the caudal extremity of the body. In the first, are two anterior and two posterior cephalic ganglia, and an œsophageal ring composed of a superior and an inferior ganglian united by lateral commissures. In the second part, situated in the tail, there are three fusiform ganglia, of like character but smaller than those of the head.

The *peripheric portion* consists of six filaments given off from the upper part of the anterior cephalic ganglia which go to as many papillæ on the head and probably organs of sense,—of two lateral cords arising from the superior œsophageal ganglion, which traverse the sides of the body, giving off filaments to the muscles, the skin, &c., and of some smaller twigs from the cephalic centres for the muscles of that region.

The *splanchnic portion* consists of two lateral trunks arising from the œsophageal ganglion, which soon meet and unite on the median line of the body, forming one cord which extends to the tail. From this cord are given off filaments to the organs of vegetative and reproductive life.

The three cords thus formed, having traversed the body, end each in one of the three ganglia above described. We can here allude to only one more point in the disposition of the nervous system; this is the final termination of the nerve-filament in muscle. According to our author, a twig enters the muscular fibre at right angles to the course of the latter, and upon its entrance divides into two twiglets, one of which runs with the fibre one way and the other the opposite, and is lost in the muscular tissue.*

The histology of this system in so minute animals as these, worked out by an observer so expert and faithful as Meissner, presents many note-worthy points.

The ganglia in question are composed exclusively of ganglion-cells or globules which appear to be the infundibuliform expansion of as many nerve fibres that compose the nervous cord connecting these ganglia with the general system. There are none of the so-called nerve-cells usually found in nervous centres—in fact these central masses rather resemble true ganglionic formations, excepting that they are terminal instead of on the course of a nervous cord. The description and figures, especially the latter, of Meissner are so good, as to leave no doubt that there is here a direct continuity of the nerve-fibre with the ganglionic vesicle.

In a former review† we alluded to some discrepancy on this point, and as this continuity had been observed by some, and yet

* As *Meissner* observes, a similar disposition is mentioned by *Doyère* (Ann. d. Sci. Nat., 1840, xiv, p. 346) in the muscles of the Tardigrada, and by *Quatrefages* (ibid. 1843, xix, p. 300) in the Eolidina, some Annelides and Rotatoria.

† This Journal, Sept. No., 1853, p. 258.

not seen by others who had searched carefully for it, we suggested that this direct connection, when present, might be an exceptional condition. But numerous researches since published, and especially the very complete memoir of Axmann,* represent this as a very common form of disposition of the elements of nervous centres in man and the mammalia. The subject is indeed somewhat obscure in a functional point of view, for what is the interpretation of this direct continuity of the vesicular with the tubular portion of this system? Certainly it is not the essential condition of function between the two, or all nerve fibres would terminate in this manner and there would be no ganglionic vesicles but those having this connection. But this, as is well known, is far from being the case. We leave the subject until another time. As to the structure of the peripheric nerves, our author describes them as having at first a distinct fibrillated structure as usual, but that this last gradually disappears and the nerve appears as a homogenous cord. But from our own investigations upon the terminal nerves of some insects, we suspect that this disappearance of the true fibrillæ may have been apparent and not real; for we have, in the cases referred to, thought that the like was true, but using higher powers with some reagents, the fibrillæ were seen. We think therefore that whatever may be made of termination of the nerve-fibre, the fibrilla structure is never lost.

Digestive Apparatus.—This structure, according to Meissner, presents so many peculiarities and is so widely different from any thing observed in other animals, that we almost relinquish any attempt to give even a brief description of it, without the aid of figures. In the first place, the alimentary canal has no anal or excretory passages, and therefore the food and assimilation must be such as to leave little or no so-called fæcal matter.

From the circular buccal orifice proceeds a semi-canal a short distance, when it passes into another structure. This semi-canal is the œsophagus. The structure into which it passes is a tube quite small at first but which soon expands and is filled with a finely granular spongy-like substance, and is alternately dilated from side to side into sacs. Through this laterally varicose tube the semi-canal of an œsophagus extends to its very end. Suppose then a tube with alternate lateral dilatations, filled with a spongy substance, and through which runs a semi-canal or half-tube like an œsophageal groove. Each of these dilatations has an inversion—a folding in of its internal membrane, producing an infundibuliform body in the dilatation itself. This body opens through a prolongation of the external membrane of the dilatation, which is continuous into a tube connecting with some adipose receptacles.

* *Axmann*, Beitr. z. mikroskop. Anat. u. Phys. d. Ganglien-Nervensystems des Menschen u. d. Wirbelthiere. Berlin, 1853.

To perhaps make the matter more clear, fancy the human alimentary canal without an anal opening, with alternate stomachs throughout its course, filled with a semi-solid granular substance; and that directly through it ran a half-tube; and that each stomach had a folding in of its internal lining forming a globular body, the neck of which passed off at right angles by a continuation of the peritoneum, into a tube which connected with receptacles of nutrition;—this would convey some idea of the most singular structure of the digestive canal of these animals.

The food passes along the semi-canal or groove, is gradually absorbed by the spongy substance filling the dilatation, thence passes into the invested body by endosmotic absorption and is then conveyed as assimilated material into the fat-receptacles which lie in the cavity of the body. These receptacles are storehouses of nutriment and are particularly enlarged and developed during the larval condition,—their contents being used for the formation of the sexual parts afterwards. Now as there is no vascular system in these animals, the dispersion of the nutrient material for the growth and substance of the various tissnes must occur by permeation and endosmosis from the fat-bodies which extend over and between all the organs. This assimilation without any particular excretion is a remarkable fact; but it appears more conceivable when we bear in mind the economy of the animal. Its larval or parasitic state is like that of insects—merely preparatory for the ulterior changes of its full development. During this time its food is probably mostly pure fat which has only to be taken up and stowed away for material of the development of the reproductive organs. This last ensues during a quiescent state, and after the full discharge of the sexual functions, the animals probably die.

Genitalia.—Males.—The disparity in numbers of males and females was remarkably wide—our author having found only three males among several hundred specimens examined. He divides the internal organs into *testis*, *vas deferens*, *vesicula seminalis*, and *ductus ejaculatorius;* but these are all continuous, forming a cæcal tube stretching from the anterior portion of the body to the caudal extremity. The testis consists of the infundibuliform cæcal extremity of this tube and is lined with nucleated, epithelial (?) cells.

The external organs consist of two penises situated one on each side of the *Ductus ejaculatorius* in a sheath. They are composed of two somewhat curved half-canals disconnected when unprotruded with the internal organs; but when protracted, they form a more or less closed tube projecting beyond the external orifice of the duct.

Females.—Meissner divides the internal female organs, which are double, into five portions: *ovary*, *vitellus-organ*, *albumen-*

sac, *tuba*, and *uterus*. Their names indicate their respective functions and we can here enter into no description of their intimate structure.

In this connection should be noticed one point not a little remarkable, that is, a kind of hermaphroditism occurring in these animals.

Meissner found individuals which had perfectly well-formed internal female genital organs, but whose caudal extremity was wholly male. Thus, there were the penises, with their protractor and retractor muscles, their sheaths—in fact, all the external organs of the male, yet in these individuals no trace of internal male or of external female organs could be found. Moreover these organs present precisely the same characteristics as though in proper males and females, and had also a functional activity,—eggs being found in the ovaries, &c. But this anomaly was not ever found in the inverse sense, that is female external and male internal organs. Here then is presented the striking peculiarity of an animal having double systematically developed internal organs of one sex, and at the same time perfectly formed external organs of the other sex. This hermaphroditism, it will be seen, is like that of other animals only in name; for in these last the double sex is at the expense of the symmetry, one side being female and the other male, or it is due to modifications of analogous facts by different grades of development, thereby destroying generally the functional perfection and completeness of each or one of the forms of the sexual organs. But here we have a perfectly symmetrical female internally, with an equally symmetrical male externally, with no fusion of parts.

In regard to the development of the spermatic particles, our author's researches have been minute and quite complete. His results confirm the doctrines of Kölliker, Wagner, and our own: That is, parent sperm-cells in which are formed daughter-cells; in each of these last there is formed a spermatic particle. But Meissner is undecided if this formation occurs through a metamorphosis of the nucleus of the daughter-cell. Our own observations have led us fully to think that this nucleus is thus metamorphosed, as we have expressed in a former review.*

The development of the egg is quite note-worthy, as it shows, what we have before never clearly understood, viz: how botryoidal ovular masses are formed, and moreover carries out the beautiful analogy existing even to minute details, between the functions of the parent sperm-cell and the ovular cell. An ovular or egg-cell from the ovary is seen; it increases in size and its nucleus segments, several nuclei being formed. These nuclei approach the surface of this which we will now call the parent egg-cell; deverticula are given off from the cell-wall by a protrusion contain-

* This Journal, Nov., 1853, p. 393.

ing each a nucleus. These protrusions become constricted and at last appear as little, or daughter-cells, on the surface of the parent-cell. They now increase at the expense of this last, become pedunculated, and finally appear as larger pedunculated cells attached around a common, insignificant centre. These are the ova and form groups of variable number—Meissner having observed even twenty, though there are generally less. Thus formed, their peduncles break off and they pass from the ovary proper into the other sections of the genital tube.

There is one other point taken up in this connection by Meissner, and to which we briefly allude as it has been a subject of discussion on a former page.* We refer to the wonderful *Micropyle* of Keber, whereby it is alleged that the spermatic particles penetrate the interior of the egg and impregnate it. Meissner has seen nothing to justify the view that such a structure exists in the eggs of *Mermis* excepting the remains of the peduncle above mentioned, and this he is not sure of being hollow. Moreover even if it were hollow, it appears to us wholly different from the special structure insisted upon by Keber.

As to the embryonic development of *Mermis*, our author found nothing essentially different from what had been described by previous observers upon this order, (Grube, Leidy, &c.) There appears to occur no proper metamorphosis, and therefore the newly hatched embryos more or less closely resemble in form, &c., the adults.

In conclusion, we repeat what we said in the beginning, that this memoir is one of the most excellent of its kind we have ever seen, and the care, patience and fidelity displayed therein will ensure attention towards its author as one from whom much may be expected.

Art. XX.—*Correspondence of M. Jerome Nicklès, dated Paris, April* 30, 1854.

Death has recently made great havoc among the ranks of science in France. In the month of March alone, the Academy of Sciences lost two navigators, an astronomer, and a celebrated surgeon. Three of these eminent men died at an advanced age; the fourth, M. Mauvais, the astronomer, was but 45 years old, and came to a tragical end. They have been co-laborers in the common field, and we shall do a public service by giving some details of their life and labors.

Doctor Roux was born in 1780 at Auxerre. In 1795 his attainments in surgery were already so great that he was admitted as an assistant surgeon in the armies of the Republic. In 1797 he came to Paris and

* See a review on the doctrines of impregnation, in this Journal, Nov. No., 1853, p. 393.

gained the friendship of Bichat. In 1806 he entered as surgeon into the hospitals of Paris, and from that time he devoted himself with much distinction to the progress of his art. Endowed with great ardor and extraordinary activity, he was equally successful in scientific literature and in the amphitheater of surgery. He contributed much to the progress of this branch of the curative art, and was one of the first to give due prominence to the department of surgical anatomy. One of the most important processes brought forward by him, was the method of producing a union of the palate, (Staphyloraphy) an operation for the purpose of giving powers of speech to persons with a divided palate. The first person upon whom he performed this operation was an American physician, Dr. Stephenson, who after his cure, exhibited the operation to the Academy of Sciences.

A large number of new modes of surgical operation were contrived by M. Roux. He showed how to treat cases of lacerated perinæum, an affection before his time regarded as incurable. One of his most important specialties was the treatment of cataract, which he practised quite recently with as steady a hand as in youth. He preserved to the latest moment his characteristic vigor, and died suddenly in an apoplectic attack, distinguished as one of the greatest operators of the age.

Admiral Roussin.—The Admiral Albert Reine Roussin was born at Dijon, on the 21st of April, 1781. In 1793, at the age of twelve years, he was admitted as cabin boy to the floating battery "*République*," charged with the defense of Dunkirk. He commenced his career in the navy in the midst of engagements; and it was not until 1801 that he was able to devote himself to his studies. We will pass over the battles in which young Roussin bore a part, and which Capt. Duperrey has enumerated in detail upon the monument of the deceased. We will speak only of the services which M. Roussin has rendered to science and humanity. He made the hydrographical survey of the western coasts of Africa, rectifying the positions of the coast, and especially that of the shoal of Arguin, rendered famous by the melancholy shipwreck of the Medusa. During sixteen months on this commission, he explored about 400 leagues of coast, and published detailed charts, together with sailing directions, thereby rendering the navigation secure. In 1819, he explored the coast of Brazil, and furnished notes and directions relating to more than 900 leagues along the coast of eastern South America, thus forming "*le Pilote du Brésil*," a work which procured for him the distinction of a member of the Academy of Sciences. Admiral Roussin has added political honors to his scientific distinctions. He was Ambassador and afterwards Minister of Marine. He forced the entrance of the Tagus in 1831, and dispelled the notion then entertained, that the Tagus could not be attacked from the sea.

Admiral Roussin was a man of superior intellect, and of consummate skill in naval affairs, as expert in the art of producing as in the art of destroying.

Beautems Beaupré, the navigator, had not the double talent of Roussin. All his attention was devoted to the progress of navigation. He was born the 6th of August, 1766. He early evinced a decided taste

for naval life; and in 1791 he went with Admiral d'Entrecasteaux in the capacity of hydrographical engineer, in search of La Pérouse, on which voyage, he made a great step in the art of navigation, by substituting astronomical observations for the magnetic needle. He used the Reflecting Circle of Borda, and with much talent applied the problem relating to the angular capacity of a segment, which had been long familiar to geometricians, but had not been brought into practical use.

This long voyage was fertile in discoveries. To him is due the reconnoissance of the Kermadec Islands, the Archipelago of Santa Cruz, and of the Salomon Islands; of the coast of New Caledonia; of the island of Bougainville; of Boughton straits; nearly 300 leagues along the south coast of New Holland, and a small-boat survey of the bays of Van Diemens land, &c. &c.

These operations were finished just before the two frigates were captured by the Dutch. M. Beautems Beaupré was sent prisoner to the Cape of Good Hope, where he remained until 1796. Upon his return to France he resumed the continuation of the *Neptune de la Baltique*, which he had commenced before his departure. He afterwards published a survey of the Scheldt, and demonstrated that the seaport of Antwerp was accessible for vessels of the line of the largest class. Among the other labors of M. Beautems Beaupré, we mention only one,—namely, the hydrographical exploration of the southern and eastern coasts of France, a work which has commanded the admiration of all nautical men, and which won for its author from the English the distinguished title of the *Father of Hydrography*. The volume which records the results of this exploration received from its author the modest title of "Nouveau Pilote Francais." To him thanks are due, that the whole extent of the French coast may now be navigated with safety. In addition to these labors he collected the necessary materials for the publication of new charts of the French coasts, and brought together all the documents which might be useful hereafter in case of any new projects relative to navigation. This last labor comprises at present 527 volumes in 4to, and embraces all the documents necessary for preparing upon a gigantic scale, a plan of all the coast of France.

After the completion of these great labors in 1838, and their publication in 1843, the distinguished author aspired to a well merited repose, but he still continued to the end of his days to assist at the sittings of the Academy of Sciences, of which he had so long been one of the most assiduous members. He died in his 88th year, with the just renown of a good man.

Victor Mauvais, the astronomer, commenced life with the study of the law, but having an irresistible passion for the mathematical sciences, he renounced the duties of an advocate, and sought admission to the Observatory of Paris, to which he was nominated in 1836 by M. Arago. From that moment he gave himself exclusively to science. He discovered, successively, four comets, whose path through the heavens he watched with great assiduity during the whole time of their appearance. In the long series of observations which constitute the Archives of the Paris Observatory, the name of Mauvais is found in-

scribed upon almost every page. Of the 150,000 observations there recorded, over 30,000 are due to Mauvais.

In 1848 he was called by the department of Doubs to represent the people, and he remained in that capacity a member of the National Assembly until its dissolution. These duties did not interrupt his astronomical observations. He passed the day in parliamentary labors, and the night in observing the heavens. He had undertaken a serious labor, in the absolute determination of the position of the fundamental stars. Struck by the discrepancy which had been remarked between the right ascension of certain stars, he conceived the idea of a series of observations with the meridian circle. He had chosen two groups each of twenty stars, succeeding each other on the meridian, after an interval of twelve hours, and had observed their passage at intervals of six months, proposing to compare them afterwards with the sun in order to deduce the position of the equinoctial points. This important labor remains unfinished.

Incessant fatigues and night watchings had broken down the health of Mauvais. He suffered much from a disease of the intestines. The death of Arago and the unexpected separation of the Bureau of Longitudes from the Observatory affected him deeply. Disapproving the course taken in this case, he left the Observatory with MM. Mathieu and Laugier, son-in-law and nephew of Arago, and determined to suspend for some time his researches. Effort was made to induce him to resume his position in the Observatory; but being the friend of Laugier he preferred to share his fate. The care and anxiety which sprung from these circumstances sadly affected the health of Mauvais. From the stomach the malady went to his head, and in a paroxysm of burning fever he took his life by the discharge of a gun.

Mauvais was born at Maiche, a little village of the department of Doubs, on the 7th of March, 1809. He died the 23d of last March, and was consequently 45 years old.

The Paris Observatory.—Before the death of Arago the director of the Observatory was chosen annually. In consequence of the new measures, the Observatory will hereafter have a permanent director, and the Bureau of Longitudes will not have a voice in this nomination. Owing to these changes and to many others made in the regulations, some of the astronomers (MM. Mathieu, Mauvais and Laugier,) gave in their resignations and left the Observatory. The corps of the observers has thus been considerably changed. According to the new regulations it is to comprise, 1, A Director, 2, Four Astronomers, 3, A variable number of adjunct astronomers, pupils, and computers proportioned to the demands of the service. The director is M. Leverrier; MM. Faye and Yvon Villarceau have been named astronomers; and MM. Babinet and Goujon adjunct astronomers. A third adjunct has been lately appointed, M. Chacornac, a pupil in the Marseilles Observatory, discoverer of *Massilia* and *Phocéa*, and also author of a valuable chart of the Ecliptic. M. Chacornac entered on his duties on the afternoon of the 2d of March, and on the night of the 3d–4th of March he discovered, near the star *Spica Virginis*, a small planet which he had found at Marseilles on the night of the 4th of February, and marked upon one of the charts of the Ecliptic. The same planet was observed

on the second of March, by Mr. Marth, at the Observatory of Mr. Bishop, in London, and named *Amphitrite.*

Electricity.—Apropos to the notice which we have given in the No. for March, p. 265, on the passage of two unlike electrical currents over the same wire, the Abbé Moigno states the following fact mentioned in his treatise on the electrical telegraph and established by MM. Breguet and Gounelle, the 7th of April 1847. These experimenters attempted to send at the same moment telegraphic signals in inverse order, over the line from Paris to Rouen. The signals were reproduced on either side with the most perfect exactness. This experiment was many times repeated, and before a Commission of the Chamber of Deputies, and the circuit was always complete. It may be objected to this fact that the signals were not exchanged at the same indivisible instant, and that it only proves that the currents were of unequal intensity. Notwithstanding the adverse opinion of many physicists, it does not appear to us impossible that two electrical currents may circulate over a conducting wire at the same time, the proof of which will be found in the experiment cited in this Journal for March, p. 266.

The decomposition of water, the process of which is not always as simple as it would seem to be from theory, has received new light through a recent discussion. When care is taken thoroughly to refrigerate the acidulated water, which is the subject of experiment, it is remarked that the volume of the gases is no longer in the relation of 1O : 2H, as theory requires; but the hydrogen is apparently in excess, owing to a notable portion of oxygen being retained by the water. This fact has been simultaneously and separately determined by MM. Jamin, Leblanc, and Sozet.

M. Ch. d'Almeida, Professor of Chemistry in the Lyceum of Henry IV, has investigated the question *whether the deposit of copper found in a solution of the sulphate of that metal when subjected to electrolysis is the product of electrolytic decomposition, or of the decomposition of the copper salt by nascent hydrogen?* By very ingenious experiments, the details of which cannot be given here, M. d'Almeida has proved that in a neutral solution, the neutrality of which is carefully preserved during the operation, the metal deposited at the negative pole is essentially derived from the direct decomposition of the salt. In acid solutions, on the contrary, the reduction is the result of nascent hydrogen. These results lead to the important practical conclusion, that in the electro-chemical decomposition of a metallic salt by the battery, the solutions should be preserved as neutral as possible. This observation is specially applicable in the study of electro-chemical equivalents.

M. Gaugain has studied some of the forms of batteries with reference to the causes which produce variation in the electro-motive force. In comparing the several couples of a thermo-electric battery, he detected between them a variation equal to 12 or 14 per cent. of the mean electric force. He ascribes this variation to a difference in the texture of the Bismuth, which is more or less crystalline according as the metal has been cooled more or less rapidly. These comparisons were made by means of a galvanometer interposed between the couples placed in opposite relations, so that each cup of the galvanometer receives the + pole of one couple and the − pole of the other.

M. Gaugain has also compared the battery of Wheatstone with that of Daniell, adopting the method of the opposition of piles. According to this observer, in Wheatstone's battery, the cause which has the most influence upon the electro-motive force is the diaphragm. This cause does not affect the electric force of Daniell's battery, which like other batteries employing two fluids, is modified by the phenomena of chemical affinity. The author has observed that the electro-motive force of Daniell's battery is diminished by the agitation of the solution in which the zinc plate is placed.

Various Memoirs.—Among the numerous communications which have been made to the Academy, there are new facts relating to the absorption or non-absorption of the nitrogen of the atmosphere by plants. M. Boussingault rejects the theory of absorption, which his numerous experiments have failed to verify, and M. Dumas agrees with him in opinion. But a young chemist has appeared, who sustains with courage the opposite view, and appeals to many facts and experiments in his support. On which side is the truth? The question is too nearly poised, soon to be solved. The debate has produced a sensation equalled only by that of another memoir—one on the preparation of Aluminium, by M. H. St. Claire Deville. Deville, who is skillful in applying heat above all French chemists, has contrived a method of preparing aluminium economically, similar to the process for obtaining potassium and sodium, using a very high temperature. We propose in another communication to give views of the lamp and forge which Deville uses in his laboratory for fusing the most refractory bodies. The note of Deville has brought out a number of communications on the subject of the economical preparation of Aluminium, none of which have yet been verified, and we wait for positive facts before touching upon them.

While Deville has been occupying himself with Aluminium, his assistant, M. Debray, has been studying Glucinum, which metal (as well as Aluminium) M. Wöhler was the first to obtain separate, although in an impure state, if we may judge from the properties of this metal mentioned by M. Debray. According to this chemist, Glucinum is lighter than Aluminium; its specific gravity is 2·1. It looks like zinc, but is less fusible, non-volatile, unalterable at the ordinary temperature and oxydizes on the surface at the blowpipe temperature without affording the phenomena of ignition produced under the same circumstances by zinc and iron. Concentrated nitric acid attacks it only when hot, and diluted acid under no circumstances. Chlorhydric and sulphuric acids, even diluted, dissolve it, disengaging hydrogen. Potassa dissolves it even when cold; ammonia is without action.

Table Turnings.—Much interest has been excited by a paper of M. Chevreul's to the Academy of Sciences, taken from the introduction of a work now in press, in which he treats of the phenomena of table-turnings. This distinguished chemist does not confine himself to this subject alone, but connects with it, the "Exploring Pendulum," and "Divining Rod," and he endeavors to reduce these phenomena to certain rational facts. In 1812, he noted the phenomena of the pendulum in a letter addressed to Ampère, and showed that the pendulum movement was produced only when the eye of the experimenter was fixed

on the instrument; and he endeavored to prove thereby that the motion was due to a play of the muscles. The work of M. Chevreul should properly be read and submitted to a commission; but some members of the Academy have objected to the consideration of a subject connected to such an extent with superstition. M. Chevreul believes that the question may be treated without going out of the domain of true science, agreeing with Arago and Faraday, and regards it not unworthy of a man of science to occupy himself with any demonstrated facts in order to search out their relation to other facts.

Works of Arago.—The works of Arago have begun to appear, published by Gide and Baudry. The first volume is on sale. It opens worthily the remarkable series of papers which will appear successively in the 12 volumes to be issued, as the posthumous works of a man who like Franklin was distinguished both in the State and in Science. This two-fold character of the man will appear throughout the published pages. The first article is entitled "The History of my Youth." It is in fact a romance, in which are interwoven the adventures of Arago in Spain, and also piquant details relating to many of the principal scientific subjects of the epoch. It contains also his Eulogies on Fresnel, Volta, Young, Fourier, Watt, and Carnot. Each of these eulogies is at the same time a complete treatise on one or several branches of science, illustrated by the life of the person of whom it treats. Thus under that of Fresnel, we find the most recondite questions in optics treated with a perspicuity and charm which render it attractive and intelligible to persons in the least familiar with this branch of study; as for instance, *Double Refraction*, *Polarisation*, *Diffraction*. In the eulogy of Watt, the *Steam Engine* is the subject; in that of Volta, it is the *Galvanic pile;* in that of Fourier, it is *Heat;* that of Carnot, it is mechanics in general, and military engineering; in that of Young, the subject of the interference of light, and Egyptian hieroglyphics. There are also other points touched upon, which give the eulogies a historic interest; as with Carnot, who organized the victorious republican armies, and with Fourier, the friend of Kleber in Egypt, who took a part too direct to be passed unnoticed, in the great events at the close of the last century and commencement of this. No one better than Arago appreciated these great characters. He has depicted with the hand of a master, the services they rendered to the cause of humanity, their discoveries in science, and their virtues.

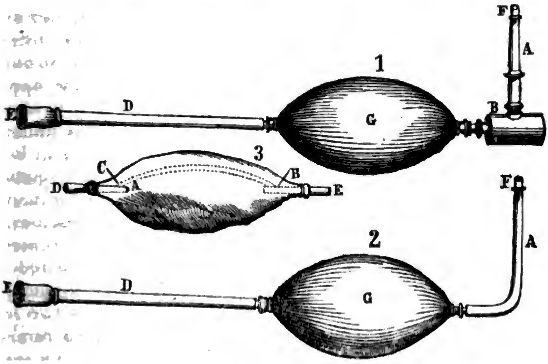
The volume is preceded by an introduction by M. Alexander von Humboldt, whose friendship for Arago dates back nearly half a century.

Poisonous effects of Carbonic Oxyd.—At the World's Fair at London, there were exhibited certain samples of iron and steel, of peculiar property, prepared by means of spongy iron, which was obtained by reducing the ore by using a mixture of hydrogen and carbonic oxyd produced by the action of steam on incandescent charcoal. The iron thus prepared, is very oxydizable, and decomposes water with an energy far exceeding ordinary iron. The author of the process, M. Chenot, proposes to use this spongy iron in obtaining aluminium, and he promises even to prepare this metal at the order of the Academy, by the kilogram for industrial purposes. We state this by way of introduction, in order to justify the observation communicated by this same

chemist, relating to the poisonous effects of carbonic oxyd. Having been for many years occupied with this gas, he has proved upon himself its deleterious qualities; and he announces that he is at this very time suffering from a new poisoning with this gas. Mixed with atmospheric air, the gas is little dangerous, but in the pure state it is a violent poison. The person taking it, says the author, falls as if struck by lightning; his eyes roll up in their sockets, his members become stiffened, the skin discolored, the veins inflated and looking blackish under the skin; the sensibility becomes extreme, and life is exalted in activity: the brain seems to be compressed, and terrible pains are felt in the thorax. The lassitude continues general for several days; sleep becomes heavy and troubled, and there are severe cramps in the legs and toes. These effects are continued for months; the person appears sad and dejected; any noise produces a nervous shock like an electric discharge.

The antidote used by M. Chenot is gum or marsh-mallow water; bathing gives much relief. These remedies alleviate but do not remedy the effects of the poison. For several weeks, now, since M. Chenot inhaled this gas, through the breaking of a manometer, he has suffered from an insurmountable feebleness and loathing; and the least touch, even his own, produces on him severe irritation.

Blowpipe with a continued Blast.—The blowpipe here figured has the merit of enabling the operator to keep up a continued blast, without the



practise required for the ordinary blowpipe, and without fatigue. M. de Luca observes that it is only necessary to blow as in an ordinary tube. The peculiarity of the blowpipe consists in the addition of a bag of vulcanised india rubber, G, having within a valve A (fig. 3), which opens from without inward, and closes from within outward, and is placed at the extremity of the mouth-tube. The valve admits the air, but prevents it from returning. The india rubber bag, by its elasticity, throws a stream out regularly by the aperture; and it serves also in place of the ordinary condenser. Figure 1 is the blowpipe with the india rubber bag; in figure 2, the cylindrical recipient is removed.

M. de Luca is a refugee Neapolitan, and one of the directors of the *Ateneo Italico.* The application which he has here made of the vulcanised india rubber bag appears to be copied from the "Cornemuse," a picturesque musical instrument much used among the Neapolitan herdsmen.

Use of Oxygen in Asphyxia.—Two physicians, MM. Faize and Genetti, who are experimenting on the effects of gaseous bodies on the animal economy, have observed that oxygen restores life to animals in which it has been nearly extinguished, as it restores brilliancy to a burning body which is nearly out. They have operated in various cases, such as asphyxia by chloroform, carbonic acid gas, and even strangulation. When life appeared to be extinct, so that the beating of the pulse and movement of the chest were hardly sensible, they have injected oxygen into the lungs and almost immediately the effect was apparent and there was a restoration to life. In some comparative experiments, made under like conditions, they have shown that the atmospheric air was almost always without effect, and in no case can its action be compared to that of oxygen which is all-powerful and instantaneous.

Local Anesthesis.—The anesthetic experiments spoken of in my last communication, although they have not led to a successful result, still have suggested an application which appears to resolve the problem in a different manner. It is now attempted to produce local anesthesis by *cold.* The mode of operation is very simple. The ether is applied, drop by drop, to the part to be subjected to the operation, and evaporation is promoted by a current of air. The ether is believed to act only as a means of refrigeration; but however this be, the process employed by M. Richet at the Hotel Dieu in the removal of a tumor appears to have been attended with success, and it is reported with details in the medical journals. After cooling with the ether for four minutes, the surgeon, perceiving that the part was insensible, plunged in his knife and made an incision near 5 centimeters in length; and the patient felt no pain although awake, and was hardly aware of the operation.

Photography and Stereoscopy.—At one of the late sessions of the Academy, M. Claude exhibited some stereoscopic views representing groups of persons with remarkable effect. He had calculated the distance so well, that on the instant of applying the eyes to the glasses, the single image with three dimensions was seen, and not two images.

At another session, M. Elie de Beaumont, Perpetual Secretary, presented to the Academy, on the part of M. Frederic Martens, engraver and photographer at Paris, a number of photographs on paper, representing the Swiss glaciers and mountains, as the glaciers of Monte Rosa, Mt. Cervin, etc. This last mountain has the form of a pyramid, and, as the Swiss say, resembles a bayonet. The views represent this pyramid as obtuse and eroded, seemingly false if common observation is correct, but in fact right, the error being that of the observer, to whom, as has been often remarked, vertical objects, such as mountains and distant edifices, always appear steeper and more elevated or pointed than they really are.

Bath for bringing out Photographs.—Sulphate of iron has been often recommended for bringing out proofs on taking them from the camera.

The use of this sulphate excludes that of the hyposulphite of soda for the solution of the iodid of silver not modified by the light; in fact, the sulphate of iron should always be acidulated; and consequently it decomposes this hyposulphite producing a deposit of sulphur, which forms with the silver a sulphuret, especially injurious in the production of direct positive proofs. This effect will not take place if the proof has been carefully washed after leaving the bath of sulphate of iron; still the decomposition of the hyposulphite goes on spontaneously, and if the precaution is not taken of filtering the solution of hyposulphite, the same accidents occur.

To avoid this difficulty, M. Adolph Martin dissolves the iodid of silver that has been acted on by the light by using a solution of cyanid of silver in cyanid of potassium. Cyanid of potassium alone does not produce the same result; for in the presence of sulphate of iron, this simple cyanid gives origin to the ferro-cyanid of potassium, which affords Prussian blue with the least trace of sulphate of iron in excess, and tinges the proofs of an intense blue color. If on the contrary the cyanid of silver dissolved in the cyanid of potassium is used, there is produced indeed a little ferro-cyanid of potassium which in the presence of the salts of silver is decomposed, causing a deposit of hydrated peroxyd of iron of a yellow color; but it adheres but slightly to the proof, and if the quantity of hydrate is not large, a simple washing for a while in ordinary water will remove it.

A new red dye for dyeing wool.—On treating uric acid with nitric acid and then with ammonia, Proust obtained, at the beginning of this century a red substance which he called purpurate of ammonia. MM. Wöhler and Liebig have since studied this substance and separated a compound of a fine red color represented by the formula $C^{12}N^{5}H^{6}O^{8}$, which they call *murexid*. This material, which is easily prepared from alloxane and ammonia, has been applied to dyeing wool, for which it furnishes a red color richer than that of cochineal. The author of this process is M. Albert Schlumberger of Mulhouse (Haut-Rhin). His experiments have been verified by a commission from the Industrial Society of that town.

The red of murexid fixes itself on the wool without a mordant. After imbibing the alloxane, a bit of wool drying exposed then to ammoniacal vapors and afterward to the heat of a steam drum or heated iron, the red color is seen to be immediately developed. It is indispensable that the ammonia should be applied before the heat. The color is not produced if the specimen impregnated with alloxane has been heated; water removes this last, while it is wholly without action on murexid.

Although this color requires no mordant, M. Schlumberger has however found that a mordant may be useful. That which he prefers is a bath consisting of equal parts of bichlorid of tin and oxalic acid, the whole forming with water a solution marking 1° Beaumé. The mordants made with protochlorid of tin give indifferent results.

Under the action of the sun's rays, the Commission found the red of murexid to be more stable than that of cochineal, and they do not hesitate to recommend the use of it in dyeing gobelins in preference to cochineal, although the new red is just now dearer than the old, since

uric acid or alloxane are now known only in the laboratories. The price will be cheapened when it is made a branch of industry, and it is certain that guano will here find a new demand.

The red of murexid resists the action of alcohol, ether, and the acetic and oxalic acids. Muriatic, nitric and sulphuric acids destroy it; but if the destruction is not complete, the color may be restored by means of ammonia. Caustic alkalies destroy it rapidly. Reducing substances, such as protochlorid of tin, sulphate of iron, cause it to disappear; but the color may be restored by means of ammonia.

Cotton, whether with a mordant or not, whether animalized (Broquette's process) or mixed with wool, is not dyed with murexid. Impressed with the alloxane and then treated with hot iron, cotton is colored it is true of a rose tint, and the color is deepened with ammonia; but the color does not stand washing, water causing it wholly to disappear.

Silk does not take the amaranth color of murexid; it becomes yellowish rose. M. Schlumberger recognizes in this property a means of distinguishing cotton, silk, and wool.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Thermic Researches on Hydroelectric Currents.*—Under this title Favre has published the first part of an investigation which promises to throw much light upon a very obscure part of the theory of the voltaic pile. In the present memoir the author considers the calorific effects developed in the galvanic circuit in their relations to the chemical action which gives rise to the current, and to the electro-chemical decompositions which the current may produce. The results obtained are as follows.

(1.) The chemical actions generated by the elements in activity are the exclusive source of the calorific effects produced by the battery.

(2.) All the chemical actions which take place in the voltaic couple concur simultaneously in the production of the current.

(3.) The disengagement of heat produced by the passage of voltaic electricity through metallic conductors is rigorously complementary to the heat confined in the elements of the battery, to form a sum equal to the total heat corresponding simply to the chemical actions independent of all electricity transmitted.

(4.) The chemical decompositions which the passage of the electricity through the circuit may effect, always bring into play quantities of heat the same as those which accompany chemical decompositions effected by other influences. The heat brought into play in the act of these decompositions results always from a draft made upon the total heat disengaged by chemical actions in the voltaic apparatus.—*Ann. de Chimie et de Physique*, xl, 293, *March*, 1854.

2. *On the double refraction temporarily produced in isotropic bodies, and on the relation between mechanical and optical elasticity.*—Werth-

SIM has communicated an elaborate memoir upon these important subjects; we must however refer to the original paper for the details of the experiments and content ourselves with stating the results which, in the author's own words, are the following.

(1.) The double refraction artificially produced, either by traction or by compression, is, for the same substance, proportional to the linear changes which the mechanical force produces in the direction of the principal axes, and consequently is also proportional to the changes of volume of the body.

(2.) The temporary lengthenings and shortenings which a given weight produces, according as it acts by traction or by compression, are neither rigorously equal to each other, nor exactly proportional to these weights, so long as these are relatively small; but these differences disappear as soon as the weights become somewhat considerable, and long before those which produce the first sensible permanent alterations.

If we lay off the weights on the axis of abscissas and the corresponding lengthenings and shortenings upon the axis of ordinates, the first below and the second above this axis, we obtain two similar, if not equal, curves, the first of which is convex and the second concave toward the axis of abscissas. These curves insensibly become straight and for linear charges which are scarcely measurable by ordinary means, become undistinguishable from a straight line which represents the proportionality between the charges and their temporary effects. These facts are confirmed by direct experiments made by different observers, experiments the results of which were only too uncertain to clearly exhibit the truth of the law; this confirmation results especially from the experiments of Mr. Hodgkinson when we calculate them so as only to take the temporary effects into consideration, and when we pay attention to the causes of errors which influence all direct experiments made by compression.

(3.) The optic axes correspond with the mechanical axes in all truly isotropic bodies, whether they have been endowed with negative double refraction by pressure or with positive double refraction by traction. The double refraction or the difference of path of two rays, ordinary and extraordinary, may be determined very accurately by means of the dull complementary tints which the two images of a white ray take, when the principal sections of the polarizing Nicols prism and the doubly refracting analyzing prism make an angle of 45° with the direction of the force which is applied to the body placed between these two prisms. In these two cases the colors ascend with the changes following exactly the series of the colored rings of Newton; for measurements, however, we can scarcely make use of these colors of more than the first seven half rings: the colors of the transmitted rings are those of the ordinary image while the tints of the reflected rings correspond to the extraordinary image.

(4.) Making no account of the small differences which have just been pointed out, the temporary double refraction is independant of the height and length of the piece, proportional to the weight applied and to the doubly refracting power of the substance, and reciprocally proportional to its breadth and to its coefficient of mechanical elasticity.

(5.) The doubly refracting power of an isotropic substance which has become temporarily doubly refracting, cannot be expressed but by the difference between its ordinary and its extraordinary index; this difference changes its sign only according as we apply pressure or traction, which would not be the case if we wished to express the doubly refracting power by a function of the two indices other than the difference of their first powers.

(6.) The dispersion of double refraction is insensible for substances which have been submitted to experiment.

(7.) Glasses which had been submitted to the operation of compression while in a pasty state, ceased to be optically homogeneous bodies, and this alteration, entirely distinct from what is called tempering, did not always disappear by annealing.

(8.) The doubly refracting power is not the same for different isotropic substances; no connection can be established between this power and the ordinary index of refraction or even the density.

(9.) By analogy with the ordinary or mechanical coefficient of elasticity E, we call coefficient of optical elasticity C the ratio between the charge applied to the unit of surface and the double refraction which it produces; we have then the simple equation,

$$I_o - I_e = \frac{E}{C}$$

which serves to determine the doubly refracting power

$$p = \pm (I_o - I_e).$$

(10.) The value of the doubly refracting power being once known for a substance, we may use the phenomena of double refraction to determine any one of the quantities which enter into the equation

$$\pm P (I_o - I_e) = d \,.\, E \,.\, La,$$

where P is the charge, I_o and I_e are the indices for the ordinary and extraordinary ray, d is the difference of path, and La the breadth of piece employed.

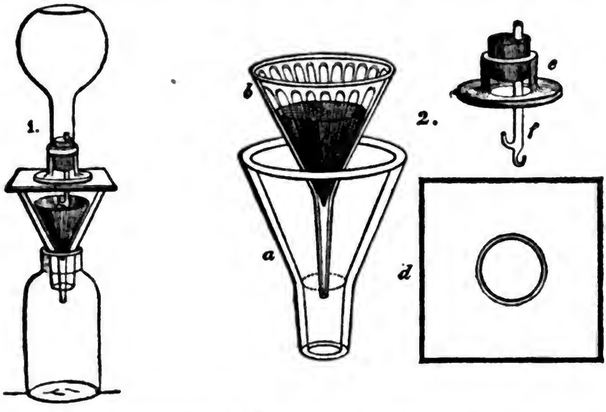
(11.) The most important of these applications consists in the determination of the force P, whatever be its magnitude and mode of action. The chromatic dynamometer gives immediately, and without the employment of any coefficient of correction, the effective pressure which is exercised by a screw press, fly-wheel, hydraulic press, lever, &c. it will serve to make known for all these machines the ratio between the useful and the theoretical effect, to graduate ordinary manometers accurately, and even to measure living forces.

(12.) The same formula would serve to determine the coefficient of mechanical elasticity if we had a direct method of finding the extraordinary index Ie; but in the mean time it has permitted me to establish the optical coefficient of the diamond, and to fix certain limits between which its mechanical coefficient is comprised.

(13.) The difference of path d being independent of the length of the undulation λ, if the ratio $\frac{d}{\lambda}$ is to remain the same for the different values of λ, P must vary proportionally to λ; which furnishes an easy method of determining the lengths of undulations, and of deciding whether a given ray is homogeneous, or what are the different simple rays of which it is composed.

(14.) The phenomena of magnetic rotation disappear in all bodies in proportion as they cease to be mechanically homogeneous and optically isotropic; it is to be remarked that among bodies which are naturally doubly refracting or which are rendered so by the employment of a mechanical force, those which have the most energetic powers of rotation are those which are at the same time endowed with the feeblest doubly refracting powers.—*Ann. de Chimie et de Physique*, xl, 156, *February*, 1854. W. G.

3. *On a new Filtering Apparatus;* by Prof. J. P. Cooke.—It is frequently important in chemical analysis to conduct the process of filtration either in vacuo or in a neutral gas, especially in an atmosphere free from carbonic acid. In order to overcome certain difficulties, I have been led to contrive an apparatus for this purpose, which, as I believe, is superior to all others now in use, both on account of its simplicity and its cheapness. The complete apparatus is represented in Fig. 1, and some of its parts enlarged appear in Fig. 2. It consists of a wide-mouthed



glass bottle, into the neck of which is firmly ground with emery a funnel (*a*, fig. 2) having a short but large spout. These are made sufficiently thick to resist the atmospheric pressure, and the rim of the funnel is ground so that the apparatus may be closed air-tight by means of a g ass plate. Within the outer funnel the common filtering funnel is placed resting loosely against its side so as to allow a free passage of air.

In order to wash a precipitate, or to produce a vacuum in the interior of the apparatus, a glass plate with a hole an inch or more in diameter drilled through its centre (*d*, fig. 2) is substituted for the covering plate. Through this passes the tube of a washing bottle (*f*, fig. 2) The washing bottle is made in the ordinary way except that it is fitted with a cork, which projects about an inch above the neck. This upper end of the cork fits the neck of a glass plate ground on the under side as is represented at *e*, fig. 2. The plate is about three inches in diameter, and when resting on the plate *d*, (see fig. 1) covers the opening completely and permits sufficient lateral motion to bring the stream of water on different parts of the precipitate. A vacuum is readily ob-

tained by connecting the apparatus with an air pump by means of a flexible tube having a brass plate at the end sufficiently large to cover the opening in the plate *d*, and by an easy manipulation the interior may afterwards be filled with hydrogen, or any other gas.

Numerous processes in which this apparatus may be advantageously applied will suggest themselves to the chemist. I have found it very useful in washing precipitates with volatile liquids, (as in the separation of fats) in preparing many metallic protoxyds, in separating the alkaline earths from alumina and sesquioxyd of iron, &c. Moreover it will be found useful in protecting both precipitate and filtrate from the dust and fumes of a laboratory in many cases even when exclusion of air is not essential. The apparatus is manufactured by the New England Glass Co., and sold by Mr. J. M. Wightman, of Boston, at a price not exceeding that of a filtering stand with brass rings.

II. MINERALOGY.

Chemical Contributions to Mineralogy; by JAMES D. DANA.

Chlorite Section of Hydrous Silicates.—Among *Anhydrous* Silicates, there is a group of species (which the writer has called the Andalusite Section), in which the oxygen of the bases exceeds that of the silica. It includes

1. Staurotide $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{1}{2}}$, Andalusite $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{2}{3}}$, Topaz $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{2}{3}}$;–Trimetric and homœomorphous.
2. Kyanite $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{2}{3}}$, Sillimanite $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{2}{3}}$; also $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{3}{4}}$, $\overline{\overline{Al}}\,\overline{\overline{Si}}^{\frac{5}{6}}$, $\overline{\overline{Al}}\,\overline{\overline{Si}}$ 1—Triclinic.
3. Euclase $\overline{\overline{R}}\,\overline{\overline{Si}}^{\frac{3}{4}}$, Sphene $(\ddot{Ti}+\dot{Ca})\,\overline{\overline{Si}}^{\frac{2}{3}}=(RO^2+RO)\,\overline{\overline{Si}}^{\frac{2}{3}}=\overline{\overline{R}}\,\overline{\overline{Si}}^{\frac{2}{3}}$;—Monoclinic.
4. Tourmaline $(\dot{R}^3, \overline{\overline{R}}, \overline{\overline{B}})\,\overline{\overline{Si}}^{\frac{3}{4}}$;—Rhombohedral.
5. Gehlenite $(\dot{R}^3, \overline{\overline{R}})\,\overline{\overline{Si}}^{\frac{2}{3}}$;—Dimetric.

Parallel with this Group, there are *Hydrous* Silicates, and they constitute what may be called the *Chlorite Section*. In a few among them, as Euphyllite, Hisingerite, and Pyrosclerite (in part), there is the ratio 1 : 1; but in all the others, the ratios are either $1 : \frac{3}{4}$, $1 : \frac{2}{3}$ or $1 : \frac{1}{2}$.

The oxygen ratios of the species, for the protoxyds, peroxyds, silica, and water, according to the most recent analyses, together with the accepted formulas, are as follows:

	$\dot{R}$	$\overline{\overline{R}}$	$\overline{\overline{Si}}$	$\dot{H}$	
Hisingerite (A), - - - -	1	2	3	2 (or 3)	$\dot{Fe}^6\,\overline{\overline{Si}}+2\overline{\overline{Fe}}\,\overline{\overline{Si}}+6\text{(or 9)}\dot{H}$
" (B), - - - -	3	1	4	3	$3\dot{Fe}^3\,\overline{\overline{Si}}+\overline{\overline{Fe}}\,\overline{\overline{Si}}+9\dot{H}$
Thuringite, - - - - - -	2	3	3	2	$2\dot{R}^3\,\overline{\overline{Si}}+\overline{\overline{R}}^3\,\overline{\overline{Si}}+6\dot{H}$
Pyrosclerite (A), - - - -	4	2	6	4	$2\dot{R}^3\,\overline{\overline{Si}}+\overline{\overline{R}}\,\overline{\overline{Si}}+6\dot{H}$
" (B), - - - -	6	4	7½	5	
Euphyllite, - - - - - -	1	8	9	2	
Margarite, - - - - - -	1	6	4	1	$\dot{R}^3\,\overline{\overline{Si}}+3\overline{\overline{Al}}^2\,\overline{\overline{Si}}+3\dot{H}$
Clinochlore, } Chlorite, } - - - - -	5	3	6	4	$\dot{R}^3\,\overline{\overline{Si}}+\overline{\overline{R}}\,\overline{\overline{Si}}+2\dot{Mg}\,\dot{H}^2$
Delessite, - - - - - -	2	2	3	2	
Ripidolite, - - - - - -	3	3	4	3	$3\dot{R}^3\,\overline{\overline{Si}}+\overline{\overline{R}}^3\,\overline{\overline{Si}}+9\dot{H}$
Aphrosiderite, - - - - -	3	3	4	2	
Chloritoid (A), - - - - -	1	2	2	1	$\dot{R}^3\,\overline{\overline{Si}}+\overline{\overline{Al}}^2\,\overline{\overline{Si}}+3\dot{H}$
" (B), - - - - -	1	3	2	1	
Cronstedite, - - - - - -	1	1	1	1	
Sideroschisolite, - - - -	0	2	1	1	
Clintonite,* - - - - - -	3	5	2	1	

* The analyses of this species by Meitzendorff give the oxygen ratio for $\dot{R}$, $\overline{\overline{R}}$, $\overline{\overline{Si}}$, $\dot{H}$, 12·22 : 20·52 : 8·64 : 3·85, which equals quite closely 3 : 5 : 2 : 1.

It will be observed that in several of the above formulas the two silicates of the formula differ widely in oxygen ratio; thus, in Ripidolite, the protoxyd silicate has the ratio 1 : 1; while the peroxyd has the ratio $3:1 = \bar{R}\,\overline{Si}^{\frac{1}{3}}$, a very doubtful possibility under any circumstances.

Viewing these same ratios in a different manner, that is, taking the ratio between the sum of the oxygen of the protoxyds and peroxyds and that of the silica, more simple results are obtained, and the parallelism with the Andalusite Section of Silicates is brought out. We thus make out four groups, as follows:

1.	General	Formula	$(\dot{R}^3, \bar{R})\,\overline{Si} + Aq.$
2.	"	"	$(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{3}{4}} + Aq.$
3.	"	"	$(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{2}{3}} + Aq.$
4.	"	"	$(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{1}{2}} + Aq.$

In *Clintonite*, whose ratio corresponds to $3\dot{R}^3$, $5\bar{\ddot{A}}l$, $2\overline{Si}$, $3\dot{H}$, if $2\bar{\ddot{A}}l$ replace silica, the species has the general formula $(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{2}{3}} + Aq.$, like Chloritoid (A).

Again, in *Thuringite*, if one third of the alumina replace silica, the formula may be $(\dot{R}^3, \bar{R})(\overline{Si}, \bar{\ddot{A}}l)$ analogous to that of Hisingerite.

Writing out the proportion of $\dot{R}^3$ to $\bar{R}$, these formulas become:

Group I. *General Formula* $(\dot{R}^3, \bar{R})\,\overline{Si} + Aq.$

Hisingerite (A),	$\dot{Fe}^3\,\overline{Si} + 2\bar{Fe}\,\overline{Si} + 9\dot{H}$	$= (\frac{1}{3}\dot{Fe}^3 + \frac{2}{3}\bar{Fe})\,\overline{Si} + 3\dot{H}$
" (B),	$3\dot{Fe}^3\,\overline{Si} + \bar{Fe}\,\overline{Si} + 9\dot{H}$	$= (\frac{3}{4}\dot{Fe}^3 + \frac{1}{4}\bar{Fe})\,\overline{Si} + 2\frac{1}{4}\dot{H}$
Thuringite,	$\dot{Fe}^3\,\overline{Si} + \bar{R}(\overline{Si}, \bar{\ddot{A}}l) + 3\dot{H}$	$= (\frac{1}{2}\dot{Fe}^3 + \frac{1}{2}\bar{R})(\overline{Si}, \bar{\ddot{A}}l) + 1\frac{1}{2}\dot{H}$
Pyrosclerite (A),*	$2\dot{R}^3\,\overline{Si} + \bar{\ddot{A}}l\,\overline{Si} + 6\dot{H}$	$= (\frac{2}{3}\dot{R}^3 + \frac{1}{3}\bar{\ddot{A}}l)\,\overline{Si} + 2\dot{H}$
Euphyllite,	$\dot{R}^3\,\overline{Si} + 8\bar{\ddot{A}}l\,\overline{Si} + 6\dot{H}$	$= (\frac{1}{9}\dot{R}^3 + \frac{8}{9}\bar{\ddot{A}}l)\,\overline{Si} + \frac{2}{3}\dot{H}$

II. *General Formula* $(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{3}{4}} + Aq.$

Pyrosclerite (B),	$3\dot{R}^3\,\overline{Si}^{\frac{3}{4}} + 2\bar{R}\,\overline{Si}^{\frac{3}{4}} + 7\frac{1}{2}\dot{H}$	$= (\frac{3}{5}\dot{R}^3 + \frac{2}{5}\bar{R})\,\overline{Si}^{\frac{3}{4}} + 1\frac{1}{2}\dot{H}$
Clinochlore,† Chlorite,	$5\dot{R}^3\,\overline{Si}^{\frac{3}{4}} + 3\bar{R}\,\overline{Si}^{\frac{3}{4}} + 12\dot{H}$	$= (\frac{5}{8}\dot{R}^3 + \frac{3}{8}\bar{R})\,\overline{Si}^{\frac{3}{4}} + 1\frac{1}{2}\dot{H}$
Delessite,	$\dot{R}^3\,\overline{Si}^{\frac{3}{4}} + \bar{R}\,\overline{Si}^{\frac{3}{4}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\bar{R})\,\overline{Si}^{\frac{3}{4}} + 1\frac{1}{2}\dot{H}$

III. *General Formula* $(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{2}{3}} + Aq.$

Ripidolite,	$\dot{R}^3\,\overline{Si}^{\frac{2}{3}} + \bar{R}\,\overline{Si}^{\frac{2}{3}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\bar{R})\,\overline{Si}^{\frac{2}{3}} + 1\frac{1}{2}\dot{H}$
Aphrosiderite,	$\dot{Fe}^3\,\overline{Si}^{\frac{2}{3}} + \bar{R}\,\overline{Si}^{\frac{2}{3}} + 2\dot{H}$	$= (\frac{1}{2}\dot{Fe}^3 + \frac{1}{2}\bar{R})\,\overline{Si}^{\frac{2}{3}} + \dot{H}$
Clintonite,	$\dot{R}^3(\overline{Si}, \bar{\ddot{A}}l)^{\frac{2}{3}} + \bar{R}(\overline{Si}, \bar{\ddot{A}}l)^{\frac{2}{3}} + \dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\bar{R})(\overline{Si}, \bar{\ddot{A}}l)^{\frac{2}{3}} + \frac{1}{2}\dot{H}$
Chloritoid (A),	$\dot{R}^3\,\overline{Si}^{\frac{2}{3}} + 2\bar{\ddot{A}}l\,\overline{Si}^{\frac{2}{3}} + 3\dot{H}$	$= (\frac{1}{3}\dot{R}^3 + \frac{2}{3}\bar{\ddot{A}}l)\,\overline{Si}^{\frac{2}{3}} + \dot{H}$

IV. *General Formula* $(\dot{R}^3, \bar{R})\,\overline{Si}^{\frac{1}{2}} + Aq.$

Chloritoid (B),	$\dot{R}^3\,\overline{Si}^{\frac{1}{2}} + 3\bar{\ddot{A}}l\,\overline{Si}^{\frac{1}{2}} + 3\dot{H}$	$= (\frac{1}{4}\dot{R}^3 + \frac{3}{4}\bar{\ddot{A}}l)\,\overline{Si}^{\frac{1}{2}} + \frac{3}{4}\dot{H}$
Margarite,	$(\dot{R}^3, \dot{H}^3)\,\overline{Si}^{\frac{1}{2}} + 3\bar{\ddot{A}}l\,\overline{Si}^{\frac{1}{2}}$	$= (\frac{1}{4}(\dot{R}, \dot{H})^3 + \frac{3}{4}\bar{\ddot{A}}l)\,\overline{Si}^{\frac{1}{2}}$
Cronstedite,	$\dot{R}^3\,\overline{Si}^{\frac{1}{2}} + \bar{R}\,\overline{Si}^{\frac{1}{2}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\bar{\ddot{A}}l)\,\overline{Si}^{\frac{1}{2}} + 1\frac{1}{2}\dot{H}$
Sideroschisolite,		$\dot{Fe}^3\,\overline{Si}^{\frac{1}{2}} + 1\frac{1}{2}\dot{H}$

* The first of these formulas of Pyrosclerite corresponds to Silica 37·6, alumina 14·2, magnesia 33·2, water 14·9; the second, (which accords with the ratio obtained by Hermann). to Silica 32·6, alumina 19·8, magnesia 34·6, water 13·0. Other analyses, as those by Genth, and Smith and Brush, afford an intermediate ratio.

† Clinochlore has for $\dot{R}^3 : \bar{R}$ nearly the ratio 7 : 4, instead of 5 : 3.

These formulas belong to a single system or natural Group, and exhibit in a simple manner the relations of the species. Chloritoid and margarite are often associated together with corundum.

The second formula of Chloritoid corresponds to a recent analysis by Prof. von Kobell of a specimen from Bregratten, in the Tyrol, and to that by Dr. J. L. Smith of Asia Minor specimens.

The water is not regarded as a base in the above, excepting in the case of margarite. This independent relation of water is illustrated in other crystallized hydrous silicates. Thus *Pectolite*, has the crystalline form of hornblende; and *excluding the water*, its formula. So also *Laumonite* has in a similar manner the form and formula of Pyroxene, and in fact it is a hydrous Spodumene. Dioptase and Pyrosmalite, likewise, have the form and formula of Beryl and Eudialyte, as shown on page 211, vol. xvii, of this Journal; *Tritomite* the form and formula of garnet; while *Analcime* is a hydrous Leucite, and *Ittnerite* essentially a hydrous Sodalite. These are some of the examples among minerals, which show through homœomorphism, that the water in hydrous silicates is sometimes not a base.

In other cases, the water must be included among the bases: and this may be the fact with Apophyllite. The formula $(\dot{Ca}, \dot{K})\dddot{Si}+2\dot{\bar{H}}$ (Rose) gives 3 per cent. too little of silica. But taking the exact ratio afforded by the analyses, as deduced by Berzelius, and making part of the water basic, we arrive at the formula $\dot{R}^3 \dddot{Si}^2+2\dot{\bar{H}}=$ Silica 52·7, lime 2·60, potash 4·4, water 16·7, in which $\dot{R}^3$ corresponds to $\dot{Ca}, \dot{K}, \dot{\bar{H}}$ in the proportions 8 : 1 : 6. Datholite is a less doubtful example, giving nearly the form and formula of Sphene.

It will be observed, that in most of the species following Pyrosclerite A, if the oxygen of the water be added to that of the bases (see table, p. 128), its ratio to that of the Silica is then 2 : 1, on which ground, if the water be basic, the general formula of these species would be $(\dot{R}^3, \bar{R}, \dot{\bar{H}}^3)\dddot{Si}^{\frac{1}{3}}$.

Wöhlerite.—The formula of Wöhlerite deduced by Scheerer is $\bar{Zr}^3 \bar{Ni}+5(\dot{Na}\dddot{Si}+\dot{Ca}^3\dddot{Si})$. It is certainly improbable that the same compound should contain three members so unlike in ratio, one with the oxygen of base and acid as 3 : 1, a second with this ratio 1 : 3, and a third, of 1 : 1. The analysis gives more exactly $4\dot{Na}$ and $14\dot{Ca}$; and thence the oxygen of the silica is to that of the other ingredients as 1 : 1, giving the general formula $(\dot{R}^3, \bar{Zr}, \bar{Ni})\dddot{Si}$, in which $\bar{Ni} : \bar{Zr} : \dot{R}^3 = 1 : 3 : 6$ and affording the special formula $6\dot{R}^3\dddot{Si}+3\bar{Zr}\dddot{Si}+\bar{Ni}\dddot{Si}$, or $(\frac{6}{10}\dot{R}^3+\frac{3}{10}\bar{Zr}+\frac{1}{10}\bar{Ni})\dddot{Si}=$ Silica 31·2, niobic acid 14·3, zirconia 18·9, lime 27·0, soda 8·6.

Keilhauite.—The formula of this mineral, according to Erdmann, is $3\dot{Ca}^3\dddot{Si}^2+\bar{R}\dddot{Si}+\dot{Y}\ddot{Ti}^3$, which contains three members with the widely unlike ratios 1 : 2, 1 : 1, 1 : 6. Erdmann's analyses afford the oxygen ratio for the bases and silica, (reckoning the $\ddot{Ti}$ with the former) of 3 : 2. Sphene has the same ratio, and I have shown that this mineral is a silicate of the form $\bar{R}\dddot{Si}^{\frac{2}{3}}$, in which $\bar{R}$ or $(R^2O^3)=TiO^2+CaO$, lime replacing part of the peroxyd. In Keilhauite the lime ($\dot{Ca}$) is nearly sufficient to make a peroxyd if combined with the $\ddot{Ti}$. Consequently Keilhauite appears to be a silicate analogous to Sphene, with the general formula $(\bar{R})\dddot{Si}^{\frac{2}{3}}$ or $(\dot{R}^3, \bar{R})\dddot{Si}^{\frac{2}{3}}$.

To Table I. of this volume, page 42, add :—

Æschynite, $I:I=90°\ 34'$, $1\bar{\imath}:1\bar{\imath}=111°\ 56'$, $1\breve{\imath}:1\breve{\imath}=112°\ 28'$. The plane I is $i\breve{2}$ (∞ $\breve{P}\breve{2}$) of Rose. $a:b:c=0·67534:1:1·01$.

Zinc Vitriol. $I:I=90°\ 42'$, $1\bar{\imath}:1\bar{\imath}=120°\ 20'$, $1\breve{\imath}:1\breve{\imath}=120°\ 3'$; $a:b:c=0·5735:1:1·0123$. Near Epsomite.

Libethenite. $I:I=92°\ 20'$, $1\bar{\imath}:1\bar{\imath}=107°\ 40'$, $1\breve{\imath}:1\breve{\imath}=109°\ 52'$, $a:b:c=0·7311:1:1·0416$.

To Table II, page 47, add :—

Descloizite. Damour (Vanadate of lead, vol. xvii, of this Jour., p. 434)—$I:I=100°\ 38'$; $1\bar{\imath}:1\bar{\imath}=67°\ 36'$, $1\breve{\imath}:1\breve{\imath}=77°\ 47'$; $a:b:c=1·494:1:1·2052$. The striated planes $e\frac{3}{2}$ are here regarded as parallel to the vertical axis, which makes M a brachydome; and it becomes the brachydome $\frac{1}{2}\breve{\imath}$, having the summit angle $116°\ 25'$. Taking this as $1\breve{\imath}$ instead of $\frac{1}{2}\breve{\imath}$, the vertical axis has half the above length or 0·747, the other axes being the same.

Glaserite (Anhydrous Sulphate of Potash). $I:I=104°\ 52'$, $1\bar{\imath}:1\bar{\imath}=59°\ 31'$, $1\breve{\imath}:1\breve{\imath}=73°\ 14'$; $a:b:c=1·749:1:1·3$.

Thenardite. $I:I=103°\ 26'$, $1\bar{\imath}:1\bar{\imath}=61°\ 12'$, $1\breve{\imath}:1\breve{\imath}=73°\ 42'$; $a:b:c=1·691:1:1·267$.

Struvite. $I:I=101°42'$, $1\bar{\imath}:1\bar{\imath}=85°\ 4'$, $1\breve{\imath}:1\breve{\imath}=96°\ 50'$; $a:b:c=1·0900:1:1·2283$. The cleavage plane is here made the base, and the prism of 96° 50′ the unit brachydome. The crystals are hemihedral (or hemimorphic) in the direction of the brachydiagonal. The species belongs near Hopeite, of Section III, Table II. If the domes $1\bar{\imath}$ and $1\breve{\imath}$ be taken as the domes $\frac{2}{3}\bar{\imath}$ and $\frac{2}{3}\breve{\imath}$, (see page 48 of this volume) then $1\bar{\imath}:1\bar{\imath}=62°\ 54'$, *and the dimensions are very near those of Heavy Spar;* $a:b:c=1·6350:1:1·2283$, a here being one half greater than above.

To Table in last volume, on pp. 432, 433, add :—

Faujasite, Dimetric, Section IV; $O:1=118°\ 16'$, $O:1\bar{\imath}=127°\ 15'$.

Edingtonite, Dimetric, Section II; $O:1=136°\ 20\frac{1}{2}'$.

Gismondine, Dimetric, Section VI; $O:1=133°\ 45'$, equals $O:\frac{1}{2}$ in Scheelite.

Alunite, Rhombohedral, Section IV; $O:R=124°\ 40'$, $R:R=89°\ 10'$. One of the occurring rhombohedrons ($\frac{6}{5}$R) gives the angles of the rhombohedron of Brucite; $O:\frac{6}{5}=119°\ 57'$, $\frac{6}{5}:\frac{6}{5}=82°\ 26'$.

Levyne may be added to the Calcite Group; $O:1=136°\ 1'$. The other species of Section II are evidently closely related to the same Group.

On p. 217, last volume, "C = 106° 8′" and "C = 88° 46′" should be transposed.

In the *Dimetric System* (p. 433, vol. xvii,) the two groups of species pointed out as belonging to a distinct series of angles—one the *Rutile* Group, the other the *Idocrase* Group,—differ 3 to 5 degrees in the inclination of the base on the corresponding pyramidal planes, or twice this amount in the basal angle of the pyramids. In the former the basal angle of one pyramid is mostly 4 to 7 degrees above 90°; and in the latter 1 to 6 degrees less than 90°.

III. Botany and Zoology.

1. *The Micrographic Dictionary; a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects;* by J. W. Griffith, M.D., F.L.S., and Arthur Henfrey, F.R.S., F.L.S., &c. Part 1. May, 1854. London: Van Voorst. pp. Introd. 24, Dictionary 16, plates 4. 8vo.—The first fasciculus of a work which is likely to supply an acknowledged want, and to be extensively useful. It is intended to be completed in 12 monthly parts (2*s*. 6*d*. each), illustrated by 40 plates, and about 800 wood-engravings. The subjects to which it is devoted are: 1. Instruction in the selection and use of Microscopes and microscopic objects. 2. The characters and structure, &c., of microscopic plants and animals, and minute organs, intimate struc-

ture, &c., in both kingdoms, and also inorganic matters occurring in animal and vegetable fluids, &c. The Dictionary extends in this fasciculus only from *Acalephæ* to *Aerial Roots*. The Introduction, on the selection, use, &c., of a microscope and its accessories, which appears to be exceedingly well executed, will be completed in part 2. The plate of test objects is admirably drawn and engraved: the other plates are tolerably good. No doubt the work will be in the hands of our microscopists generally. A. G.

2. *Botany of the Voyage of the Herald;* by B. Seemann.—The 4th part, (London, Reeve, 1854,) continues the Flora of Panama from the *Lythrarieæ* to the *Compositæ*, and about half way through the latter order, which is remarkably well elaborated by Dr. Steetz of Hamburgh. To the *Passifloraceæ* Mr. Seemann has annexed the *Turneraceæ*, on the strength of characters furnished by a new Veraguan genus, *Erblichia*, Seemann. The reasons of the union are more fully explained in a short article published some time ago in Hooker's Journal of Botany. A. G.

3. *Dr. Hooker's Flora of New Zealand.* Part 5, (London, 1854, Reeve,) commences the account of the Cryptogamic Plants, which are so numerous in New Zealand. Dr. Hooker has himself elaborated the Ferns, with a bold and able hand; and his prefatory observations upon this beautiful order,—so perplexed of late by special Fern-systematists, who, some of them, propose new genera for every modification of any one organ, whether of vegetation or reproduction,—deserve an attentive consideration. Under *Hymmenophyllum Tunbridgense*, "a scarce English Fern," there is perhaps some mistake in the statement that it is "a great favorite with cultivators;" for we had supposed that no person had yet succeeded in cultivating it. Mr. Wilson has elaborated the *Musci*, in the midst of which the present fasciculus closes: seven plates are given to their illustration, and more are apparently to come. We understand that this great work will be immediately followed by the *Flora of Tasmania;* and that the first part of the Flora of India is also ready for the press. A. G.

4. *Botany of the U. S. Exploring Expedition under Capt. Wilkes: Phanerogamia*; by A. Gray. Vol. I. pp. 777, roy 4to.—This volume contains the *Exogenæ Polypetalæ*. Many new species, and the following new genera are established in it, viz:

Richella—in Anonaceæ, near Polyalthia of Blume, but with a singular winged seed.

Agatea and *Isodendrion*, in Violaceæ; the latter of three species.

Diclidocarpus, a remarkable Tiliaceous genus.

Draytonia, allied to Saurauja, but with the styles united into one.

Rhytidandra, an anomalous Olacineous genus.

Pelea, a Rutaceous (Zanthoxylaceous) genus, of seven species.

Amaroria; a near ally of Soulamea, the *Rex amaroris* of Rumphius.

Brackenridgea; a genus of Ochnaceæ.

Oncocarpus; a genus of Anacardiaceæ, with a remarkable fruit.

Streptodesmia; a near ally of Adesmia.

Luma; a new Myrtaceous genus, of numerous Chilian species.

Acicalyptus; a genus related to Calyptranthes and Eucalyptus, to which the more closely can only be known by the fruit, which, however, is probably baccate.

Astronidium and *Pleiochiton*, two genera of Melastomaceæ.

Haplopetalon; a new genus of Legnotidæ, to which group *Crossostylis* is also referred.

Spiræanthemum; of Saxifragaceæ, Cunonieæ, containing two species.

Reynoldsia (of two species), *Tetraplasandra*, and *Plerandra*, new Araliaceous genera; the two latter with numerous or indefinite stamens; a new feature in this family.

The folio Atlas, of 100 plates, is not yet issued. A. G.

5. *Dr. Wallich*, the distinguished East Indian Botanist (a Dane by birth) died in London, at the close of April last. A little earlier the venerable *Professor Reinwardt* died in Holland. A. G.

6. *On preserving the Balance between the Animal and Vegetable Organisms in Sea Water*; by ROBERT WARINGTON,* (Ann. Mag. Nat. Hist., 2nd ser., vol. xii, p. 319.)—In the published notices of my experiments of 1849, to maintain the balance between the animal and vegetable organisms in a confined and limited portion of water, the fact was demonstrated, that, in consequence of the natural decay of the vegetation, its subsequent decomposition and the mucus-growth to which it gave rise, this balance could be sustained only for a very short period, but if another member were introduced, which would feed upon the decaying vegetation and thus prevent the accumulation of these destructive products—a function most admirably performed by the various species of water-snail—such balance was capable of being continuously maintained without the slightest difficulty; and I may add, that the experimental proof of this has now been carried on, in a small tank in the heart of London, for the last four years and a half, without any change or disturbance of the water; the loss which takes place by evaporation being made up by rain or distilled water, so as to avoid any great increase of the mineral ingredients originally present. It follows then, as a natural deduction, from the successful demonstration of these premises, that the same balance should be capable of being established, under analogous circumstance, in sea water. And in a paper published in January, 1852,† I stated that I was, at that time, "attempting the same kind of arrangement with a confined portion of sea water, employing some of the green sea-weeds for the vegetable member of the circle, and the common periwinkle as the representative of the water-snail."

The sea water with which the experiments I am about to detail were conducted, was obtained through the medium of one of the oyster-boats at the Billingsgate fish-market, and was taken from the middle of the English Channel.

My first object was to ascertain the kind of sea-weed best fitted, under ordinary circumstances, for keeping the water clear and sweet, and in a sufficiently oxygenated state to sustain animal life. And here opinions were at variance, for one naturalist friend whom I consulted, advised me to employ the Rhodosperms; another stated that it was impossible to make the red weeds answer the purpose, as he had tried them, and strongly recommended the olive or brown-colored Algæ;

* Communicated by the Author, having been read at the Hull Meeting of the British Association.

† Gardeners' Botanical Magazine and Garden Companion, Jan., 1852.

while, again, others thought that I should be more successful with those which had in theory first suggested themselves to my own mind, namely the Chlorosperms. After making numerous unsuccessful experiments with both the brown and red varieties of Algæ, I was fully convinced that, under ordinary circumstances, the green weeds were the best adapted for the purpose.

This point having been practically ascertained, and some good pieces of the *Enteromorpha* and *Ulva latissima* in a healthy state, attached to nodules of flint or chalk, having been procured from the shore near Broadstairs, several living animal subjects were introduced, together with the periwinkle. Every thing progressed satisfactorily, and these all continued in a healthy and lively condition.

My first trials were conducted in one of the small tanks which had been used for fresh water; but as it was necessary, during the unsuccessful experiments with the brown and red sea-weeds, to agitate and aërate the water, which had been rendered foul from the quantity of mucus or gelatinous matter generated during the decay of their fronds, until the whole had become oxydized, and the water rendered clear and fitted for another experiment, it was, therefore, for greater convenience, removed into a shallow earthen pan and covered with a large glass shade to protect the surface of the water, as much as possible, from the dust and soot of the London atmosphere, and at the same time impede the evaporation. In this vessel then I had succeeded perfectly in keeping a large number of beautiful living specimens in a healthy condition up to the close of 1852. I therefore gave instructions for the making of a small tank as a more permanent reservoir, and one more adapted for carrying on my observations and investigations on the economy and habits of the inhabitants.

From the experience I had obtained in my experiments with the freshwater tank, I was induced to modify slightly the construction of this vessel; thus, at the back, or part towards the light, the framing was filled with slate in the same way as the ends and bottom; for I had found that the glass, originally employed, very soon became covered with a confervoid growth which had an unpleasing appearance to the eye, and in consequence of which I had been obliged to paint the glass on the exterior, to prevent this growth from increasing to too great an extent. It was also an unnatural mode of illumination, as all the light should pass through the surface of the water. The front towards the room and the observer was constructed of plate-glass, the whole being set in a stout framework of zinc, and cemented with what is known under the name of Scott's cement, and which I have found to answer the purpose most admirably. Within this tank were arranged several large pieces of rock-work, thrown into an arched form, and other fragments were cemented in places against the slate at the back and ends, and at parts along the water line, so that the creatures could hide themselves at pleasure; a short beach of pebbles was also constructed in order that shallow water could be resorted to if desired. The whole tank was covered with a light glass shade to keep out the dust and retard evaporation.

With the sea water obtained in January, 1852, I have been working without cessation up to the present time, agitating and aërating when it

became foul during the unsuccessful experiments on the sea-weeds, but since then it has been rarely ever disturbed; the loss which takes place from evaporation being made up, as before stated, with rain or distilled water.

For a considerable period, after commencing these experiments, I was much troubled to obtain living subjects in a healthy condition, but having alluded to this, and the success of my investigations, in a short notice appended to a paper published in the "Annals of Natural History" for October, 1852, my friend, Mr. P. H. Gosse, who was then sojourning at Ilfracombe for his health, offered in the kindest manner to supply me with materials, and from that period he has always most heartily responded to my wants. It must not be imagined for a moment that the beautiful creatures I have thus received have been all preserved alive or always quite healthy. In experimental investigations this would be unreasonable to expect, as the very fact of experimenting implies a disturbance of the then state of things. Besides which, from want of a sufficient knowledge of natural history, from want of forethought and experience and other causes, I have lost many very fine specimens; and as the detail of these losses may prevent the occurrence of the like annoyances to others, I shall venture to occupy your time for a short period with their history.

My greatest loss arose from too great anxiety to transfer the collection I had preseved in a healthy condition to the end of December, 1852, into the new tank. As soon as it arrived from the maker's I lost no time in introducing my numerous family to their new abode, and dearly I paid for my precipitancy, for on the next morning I found many of my most beautiful specimens dead; thus I lost two fine Holothurias *(H. Pentactes)*, a small freckled Goby *(Gobius minutus)*, a beautiful little Pipe-fish *(Syngnathus lumbriciformis)*, and several others, and on opening the door of the case the cause of this mortality was at once evident,—an iridescent film of oily matter was floating on the surface of the water, arising from the paint with which the angular joints and edges of the small tank had been colored not having become sufficiently hardened.

Another source of loss arises from the several creatures attacking and devouring each other, and it therefore becomes a point of great importance—and highly necessary to be carefully observed, where their preservation is an object—to ascertain what varieties may be safely associated in the same tank; as, for instance, I have found that the Shrimps, and Prawns attack, and very soon devour, all the larger varieties of Corallines and Polyps, Sabellæ, Serpulæ, Rock-borers, Cirrhipeds, some of the Annelids, many of Bivalve and Univalve Mollusks that are unprotected by an operculum, or have no power of closing their valves. The instances which have come under my own immediate observation have been the destruction of the *Pholas dactylus*, *Saxicava rugosa*, *Cypræa Europæa*, and several specimens of Sabellæ, Serpulæ, *Coryne sessilis* and many others.

The common Crab *(Cancer Mænas)* is likewise a most destructive agent; and the tribe of rock-fish, the Blennies, Gobies, &c. are also most voracious, devouring all the varieties of Cirrhipeds, Corallines, Polyps, Annelids, &c.; they will also attack the shrimps and prawns,

and even seize upon the horns of the periwinkle, which they bite. If the mollusks do not keep a very firm hold of the rock or tank sides, they are rapidly turned over by these fish on their backs and lie helplessly exposed to their attacks.* It is doubtless their seeking food of this kind which causes these little fish to be so generally found in the shallow rock-pools of the coast. In consequence of these ravenous propensities I have been obliged to establish several small tanks and imitation rock-pools, so as to separate these various depredators from each other: thus in one I have varieties of *Actinia*, Shrimps, Nudibranchs, Holothurias, and some Annelids; in a second the rock-fish, as the Blennies, Gobies, Cottus, with Crabs and *Actiniæ;* in a third Corallines, Annelids, Polyps, Rock-borers, Sabellæ, Serpulæ, Holothurias, and *Actiniæ.*

Another curious instance of loss I may detail which has quite recently occurred, and which may prove interesting; it was in a small rock-pool containing Blennies, Gobies, Crabs, &c. I had procured two live oysters for the purpose of feeding my numerous small fry in these Vivaria, and one of these having proved ample for the purpose of one meal, the other was placed on the sandy bottom; on the second day after this, the oyster was observed to have opened the valves of his shell to a great extent, which were afterwards seen closed, but a small *Gobius niger*, inhabiting the pool, could nowhere be seen. The day after this the oyster was opened for the general feeding, when lo! within the shell was found the unfortunate *Gobius*, quite dead. Whether this little gentleman had been attracted within the trap by curiosity or the ciliary motion of the oyster, it is impossible with certainty to say; but that he must have seized on some sensitive part of the oyster is more than probable, so as to have caused such a rapid closing of the valves of the shell as could entrap so active a burglar.

Another important point is the gravity of the sea water; this should be very carefully regulated, for it must be borne in mind that many of the marine creatures are supplied by a permeation of water through their tissues or over their delicate and beautiful organs. The specific gravity should not rise above 1026 at 60° Fahr., and a small hydrometer should be introduced at short periods to ascertain that this point is not exceeded, particularly during the hot months of summer. The reduction to this gravity can be readily effected by the addition of rain or distilled water. Many of the creatures will of themselves afford indications of this increase of density; some of the *Actiniæ* will remain closed and become coated with a white slimy covering within which they remain for a length of time, and if the specific gravity of the water be lowered this is very soon ruptured by their expansion, thrown off, and the tentacula become soon extended.

* Since the reading of this paper at Hull I have received a Blenny of larger size, being about 3½ inches in length, and although it has become so tame that it will allow itself to be touched by the hand and takes its food from the fingers, yet its destructive propensities are so great, that it very soon killed four small Crabs; and to save three others, of rather a larger size, I have been obliged to remove the Blenny to a rock-pool in association with his own species and a few *Actiniæ.* The only refuge the poor Crabs had was to bury themselves in the sand, and whenever they attempted to move out of their refuge they were immediately pounced upon and only escaped by burrowing rapidly again.

All putrescent matter or excess of food or rejecta of the *Actiniæ* should be carefully removed from the water, as the noxious gaseous compounds generated by the decay of such matters appear to diffuse themselves rapidly through the water, act as a virulent poison, and speedily destroy the vitality of the occupants. Thus many beautiful subjects were lost in a few hours from the introduction, into a small glass jar, of a large Pecten shell, encrusted with corallines, which had become loaded with putrescent matter by partial submersion in a foul muddy bottom.

Great care should also be taken in moving the *Actiniæ*, that the foot or sucking disc with which it attaches itself to the rocks, stones, or mud, be not injured, as, when this occurs, they rarely survive, but roll about without attaching themselves, and gradually waste away and die.

With these exceptions then, every thing has gone on very satisfactorily, care being always taken not to overload the water with too large a proportion of animal life for the vegetation to balance, as whenever this has been inadvertently attempted, the water has soon become foul, and the whole contents of the tank, both animal and vegetable, have rapidly suffered, and it has required some time before the water could be restored to its former healthy condition.

In one of the numbers of the "Zoologist" of last year, I stated that besides the *Ulvæ*, *Enteromorphæ* and *Cladophoræ*, I had found the *Zostera marina* a very useful plant for oxygenating the sea water; but this observation has reference only to the case of a tank supplied with a ground where its roots will find a sufficiency of food for its growth, as in a clear shingle or sand it soon decays; and it should be associated with such animals as delight in a ground of this nature, as many of the Annelids, Crabs, burrowing Shrimps, &c. There are several interesting observations which have been made from time to time connected with this subject, which I hope to lay before the natural-history world as soon as I can find leisure time for the purpose.

Apothecaries' Hall, Sept. 10, 1853.

IV. Astronomy.

1. *New Planets:—Bellona* (28), (Comptes Rend., xxxviii, 455, 561.)—On the first of March, 1854, Mr. Luther, Director of the Observatory at Bilk, discovered a new planet which has received from Mr. Encke the name *Bellona:* it is of the tenth magnitude. Its position, March $6^d\ 10^h\ 27^m\ 30^s$, M. T. Hamburg was R. A. $180°\ 35'\ 38''$ and Dec. $+7°\ 47'\ 34''$. Mean daily motion in R. A. $10'\ 7''$ decreasing, in Dec. $9'\ 26''$, increasing.

Amphitrite (29), (Compt. Rend., xxxviii, 428, 645.)—Mr. Albert Marth, at the Regent's Park Observatory in London, discovered another planet near *Spica Virginis*, on the morning of the second of March. It appears as a star of the tenth magnitude. Mr. Bishop has proposed for it the name *Amphitrite.* The following elements of its orbit were calculated by M. Yvon Villarceau, according to the method given in the *Connaissance des Temps* for 1852, from 16 observations made at Paris during the month of March.

Epoch 1854, March 0·00, M. T. Paris.

Mean anomaly, - -	114° 36′ 54″·58	
Long. perihelion, - -	64 50 22 ·81	Mn. Eqnx.
" asc. node, - -	356 20 34 ·94	Mar. 0·0, 1854.
Inclination, - - -	6 6 19 ·69	
Angle of excentricity, - -	4 34 47 ·04	
Mean daily motion, - -	864″·3666	
Semi-axis major, - - -	2·5637300	
Period of revolution, - -	4yrs·104962	

This planet was discovered independently by M. Chacornac, assistant observer at the Observatory of Paris, on the third of March. He also on the fourth of February, at Marseilles, noted a star of the tenth magnitude which is now wanting in that place, and which is shown to have been the body first recognized as a planet by Mr. Marth.

2. *New Comet, I. of* 1854, (Comptes Rend., xxxviii, 648.)—The comet which was visible to the naked eye on the twenty-ninth of March last and the few following days, was seen on the same day in Paris. The following elements were computed by Mr. James Ferguson (Astron. Journ., No. 71,) from the Washington observations of April 3, 7 and 11.

Perihelion passage, 1854, March 21·0581, M. T. Berlin.

Long. perihelion, - - -	214° 52′ 52″·0	Mn. Eqnx.
" asc. node, - -	316 19 58 ·2	Apr. 7·0, 1854.
Inclination, - - - -	83 30 33 ·4	
Log. perihelion dist., - -	9·141070	
Motion, - - - -	Retrograde.	

This comet was seen in the east on the morning of the twenty-third of March by Mr. Alfred de Menciaux near Damazan in France.

3. *Annular Solar Eclipse of May* 26, 1854.—From a communication in the Boston Evening Traveler, May 29, 1854, we gather some of the following particulars respecting the solar eclipse of May 26, 1854. On account of cloudy weather, the eclipse was but partially observed throughout New England, and in many places wholly lost. At Cambridge, Mass., the formation of the ring was observed and it occurred within seven seconds of the time predicted by R. T. Paine, Esq. in his communication to the American Academy,—which is a remarkably close coincidence. The formation and rupture of the ring and the two other contacts were concealed by clouds. "At Middlebury, Vt. where the eclipse, by calculation was central, the beginning of the eclipse could not be seen, but the formation and breaking of the ring and the end of the eclipse were finely observed, and the spectacle was magnificent." At the Coast Survey station on the summit of Mount Agamenticus, nearly in the central line, the sun was invisible throughout the day.

At New York City, Ogdensburg, and Washington, the sky was very favorable, and good observations of the phenomena were secured, including numerous heliotypic pictures with the times of each.

Effect on the Deviation of the Magnetic Needle.—Mr. J. G. Ellery sends us an account of observations made by him at Morgantown, Burke Co., N. C., on the deviation of the magnetic needle. The instrument with which his observations were made was a miner's compass,

with a needle between two and three inches in length, possessing the delicacy of movement of the best surveyor's compass, but without levels or vernier. The weather was warm and sultry, with indications of rain from some of the large clouds in different parts of the heavens; but with hardly air enough stirring to move a leaf. No motion of the needle was observed between 1 P. M. and 4 P. M. Soon after it was observed to shift its position toward the west, and at 5¼ it had attained its greatest variation, pointing then more than half a degree to the west of north. The variation decreased from that time till a quarter past six, when the needle was again precisely on the meridian. In the circumstances of the observation it seems quite uncertain whether the movement of the needle was not due to other causes than the interception of solar influence.

Lieut. MAURY (Ast. Journ., No. 72) communicates the observations made at the Washington Observatory:—

Beginning by Mr. Ferguson, - -	$4^h\ 2^m\ 37^s{\cdot}57$
End, " - - -	6 27 26·46
" by Prof. Keith, - - -	6 27 29·64

Mr. Ferguson observed with the large equatorial, and Prof. Keith with the west transit instrument, lifted from its Ys and mounted on the reversing apparatus. The computed times for beginning and end were $4^h\ 2^m\ 41^s{\cdot}4$ and $6^h\ 27^m\ 29^s{\cdot}4$.

Prof. JAMES CURLEY (Astr. Journ., No. 72) furnishes the observations made at the Georgetown Observatory. The last contact was observed by Prof. Sestini with the equatorial, using a power of 25 or 30, in order to have the whole sun in the field of view. The time was determined with the meridian circle from the transit of the sun on the 26th, and after applying the necessary corrections was determined to be for the last contact $6^h\ 27^m\ 22^s{\cdot}67$, Georgetown Mean Time. Lat. 38° 54′ 26″ N., Long. $5^h\ 8^m\ 18^s{\cdot}2$ west of Greenwich.

Effect on the Magnetic Intensity; by LEWIS R. GIBBES.—The condition of the atmosphere throughout the day was unfavorable to nice observations, and we have but few positive results to record. Though the face of the sun during the eclipse was not observed, yet a thin hazy cloud overspreading its disc, and the western part of the sky, and the accompanying unsteadiness of the atmosphere in refractive power, kept the limbs of both sun and moon in a state of constant agitation. This tremulons condition of the limbs prevented the study of those remarkable phenomena sometimes seen at the contact of the limbs of the two bodies.

The beginning of the eclipse was observed at $3^h\ 58^m\ 31{\cdot}4^s$ mean time at Charleston Observatory, the end at $6^h\ 19^m\ 08{\cdot}8^s$. Place of observation, the College. Magnifying power used, 55. Screen glass, green and light red combined. No unusual phenomena observed; limbs tremulous at both contacts. No spots, either dark or bright, to be seen on the sarface of the sun. No prolongation of the moon's limb beyond the sun's disc was observed, nor any alteration of the form of the cusps; nor was the moon seen before the contact of limbs, through either the white or colored screens.

The temperature and transparency, or rather transcalescency of the atmosphere was so constantly varying, that no results of interest could be obtained with reference to the eclipse.

Within the last two or three years, M. Lion, Professor of Physics at Beaune, in France, has maintained that the intensity of the magnetic force of the earth is increased during a solar eclipse. To test this, observations were made during the late eclipse with the following apparatus: A magnetic bar, 4½ inches long and ¼ of an inch square, weighing 400 grains, was placed in a stirrup of thin sheet brass—the two together weighing 410 grains—and, by a hook of fine wire, was suspended by 5 fibres of untwisted silk, 10 inches in length; the whole was protected by a glass receiver from agitation by currents of air, or other causes of disturbance. This apparatus was mounted on a firm stand, and placed on the stone floor of a room, in the basement story of the College, used for storing the coal for the laboratory, empty packing boxes, &c., though by no means to be regarded as a coal hole; yet may not experiments be carried on in a coal hole, if no better place can be had? A few feet north of it was placed a table for the record book, chronometer, and a small telescope, whose axis coincided with that of the magnetic bar when at rest. The time required by the magnet to accomplish 100 oscillations or double vibrations were observed at intervals during the day; the end of one oscillation, and the beginning of the next, being taken at the instant that the axis of the magnet coincided with that of the telescope, the north end of the magnet swinging from west to east. The results are contained in the following table. The approximate interval for 100 oscillations was 17¼ minutes. The first column of the table gives the time of the phases of the eclipse and of the middle of each interval occupied by 100 oscillations; the second column, the precise length of interval of each 100 oscillations.

Date.	Interval of 100 oscillations.
h. m.	min. sec.
26th—10 08, A. M.	17 15·93
12 25, P. M.	General eclipse begins.
12 51, "	17 16·20
1 08, "	17 15·58
1 25, "	17 14·80
3 16, "	17 15·64
3 35, "	General eclipse middle.
3 59, "	Eclipse begins at Charleston.
4 31, "	17 15·98
4 48, "	17 16·10
5 09, "	Eclipse middle at Charleston.
6 01, "	17 15·56
6 18, "	17 15·94
6 19, "	Eclipse ends at Charleston.
6 20, "	General eclipse ends.
29th—12 30, "	17 15·12
12 47, "	17 15·15

The observations were begun on the 26th, two hours before the beginning of the general eclipse on the earth, and continued at intervals until it ended, and two more were taken on the 29th. The results give no indication of any sudden or unusual change in the magnetic intensity during the eclipse; the intervals are not all precisely equal, but their deviations from coincidence are not greater than what are due to una-

voidable errors of observation, to imperfection in the apparatus used, and possibly to ordinary causes of disturbance. The second, third, and fourth results, which appear to be regularly diminishing, were obtained in close succession, the instant of ending the first 100 oscillations being the beginning of the second 100, and the end of the second 100 being the beginning of the third 100, as will be seen by the differences of the times, being 17 minutes. Their diminution is due to the gradually diminishing arc of vibration, the initial arc being somewhat large —8 or 10 degrees—in order to allow of 300 continuous vibrations. A more delicate suspension would have been desirable. The initial arc in the other cases was about 5 degrees, and the observations continued to 200 oscillations, except in the first and fifth results. We may from these results draw the conclusion that there were no disturbances of the magnetic intensity due to the occurrence of the eclipse, although the strictly logical deduction is, that if such disturbances existed, they were too minute to be detected by the apparatus used.

M. Lion has also maintained that this disturbing influence of a solar eclipse may be perceived at places where the eclipse is not visible. This point we examined with the same apparatus above described, at the occurrence of the solar eclipse of 6th June, 1853, which was not visible at Charleston, the northern edge of the penumbra passing just south of this city. The results are contained in the following table with the same arrangement as the preceding.

Date. June, 1853. h. m.	Interval of 100 oscillations. min. sec.
5th—8 09, A. M.	17 17·09
7 00, P. M.	17 16·88
6th—8 08, A. M.	17 18·45
8 25, "	17 18·00
11 47, "	General eclipse begins.
12 05, P. M.	17 16·88
12 22, "	17 17·23
2 38, "	General eclipse, middle.
3 00, "	17 18·02
4 00, "	17 18·18
5 47, "	General eclipse ends.
6 35, "	17 18·83
10 00, "	17 18·66
8th—8 00, A. M.	17 17·82
10 00, "	17 17·36

These results show no disturbance proceeding from the occurrence of the Solar Eclipse, and we cannot avoid the conclusion that the Professor at Beaune has in some way mystified himself in his observations, especially as his instrument was, if we mistake not, an ordinary magnetic compass, and therefore far less fit for such observations than the above described apparatus.

Each result in the above tables is the mean of *five* sets taken in the mode usually adopted in such observations, except the first in the first table, which is a mean of three. More, therefore, than 5000 oscillations, or more than 10,000 vibrations have contributed the results in the first table, and more than 12,000 vibrations the results of the second table.

College of Charleston, 1st June, 1854.

4. *Eclipse of the Sun, May* 26, 1854, *at Yale College*, (Lat. 41° 18′ 23″, Lon. 4h. 51m. 47s.)—The previous day was rainy, but it cleared off in the night, and the morning afforded so pure and clear a sky as to inspire high hopes of a most favorable time for observing the eclipse. But by noon a strong northwesterly wind began to bring up ridges of cumulus clouds which, as the time of the eclipse drew near, left only here and there a patch of clear sky and prevented our obtaining the first contact, although Mr. Francis Bradley who observed separately with his reflector, had a momentary glimpse of the sun at 4h. 19m. 47s. M. T. when the eclipse had advanced a few seconds. Messrs. Lyman and Newton used the Clark Telescope with a power of 110. No spots were visible, but the mottled appearance of the sun was very distinct, and the definition good. When the sun was first seen emerging from a cloud, the eclipse had advanced perhaps 15 or 20 seconds. Clouds and clear sky alternately obscured and revealed the sun until five o'clock, after which the view was unobstructed.

The *end* was closely observed by Mr. Bradley with a power of 80 and by Mr. Lyman with 110, but the limb, being now near the horizon, was so broken and wavy that the instant of last contact could not be determined within several seconds. The time fixed upon was 6h. 42m. 19s. This is probably within from 5 to 8 seconds of the truth.

Mr. Lyman remarks, that with the Clark Telescope (aperture 5 inches) the moon's limb during the early part of the eclipse, was well defined, the lunar mountains being projected with great distinctness on the sun's disk. Two or three times near the middle of the eclipse, the extreme points of the cusps were observed to be momentarily cut off by projecting mountains. No other important physical phenomena were noticed by him, though the cusps and limbs of the sun and moon were carefully watched at frequent intervals. Mr. Newton could detect no signs of polarization with a double image prism.

Professor Olmsted occupied himself with the meteorological instruments, and the general aspects of the earth and sky. He was favorably situated on the top of a high tower where an unobstructed view was enjoyed on all sides. As the eclipse advanced to the maximum (nearly 11 digits) the shadows became less deep, the color of the grass and trees, now at the height of their summer verdure, wore an increasing olive hue, and a sublime and strange appearance invested all things. Having, however, witnessed the total eclipse of June, 1806, and retained its appearances very fresh in memory, he remarked that there was an immense difference between a total eclipse of the sun, and one only *almost* total, the former being vastly more sublime and impressive.

The meteorological instruments, including the barometer, two thermometers, (one in the sun the other in the shade,) and a delicate azimuth compass, were noted at short intervals, but none of the observations suggested any thing important, except that the thermometer exposed to the direct action of the sun rapidly fell as the eclipse advanced, and at the maximum, differed only two degrees from that in the shade, the former being 69½° and the latter 67½°. At 3h. 16m. the solar thermometer had stood at 92½°, and just after the beginning of the eclipse when the sun came out of a cloud, it stood at 82°. The sensations indicated a perceptible decline of temperature, but nothing of that chill was experienced which characterized the total eclipse of 1806. O.

V. Miscellaneous Intelligence.

1. *American Association for the Advancement of Science.*—This Association held its annual meeting at Washington, in the rooms of the Smithsonian Institution, during the week commencing with Wednesday the 26th of April, 1854. James D. Dana was the President of the meeting. Prof. J. Lovering, of Cambridge, Permanent Secretary, Prof. J. Lawrence Smith, General Secretary. Prof. John Torrey was elected President for the next meeting, which was appointed to be held in Providence, R. I, on the 3d Wednesday of August, 1855.

The following is a list of the papers read at the recent session:

(1.) *Physics, Astronomy, Geodesy, &c.*

Comparison of the diurnal inequalities of the tides at San Diego, San Francisco, and Astoria, on the Pacific coast of the United States, from observations in connection with the Coast Survey. By *A. D. Bache*, Superintendent.

On the resistance experienced by bodies falling through the Atmosphere. By Prof. *Elias Loomis*, University of New York.

Electric properties of whalebone rubber. By Mr. *John M. Batchelder*, Superintendent of the Crystal Palace (communicated by Prof. Peirce).

Preliminary determination of cotidal lines on the Atlantic coast of the United States, from the Coast Survey tidal observations. By *A. D. Bache*, Superintendent.

Earthquakes of Chili. By Lieut. *Gilliss*.

On the physical constitution of the sun and cometary bodies. By Prof. *W. A. Norton*.

On the periodic and occasional perturbations of the directive force of the declination of the magnetic needle By Prof. *W. A. Norton*.

On the magnetic forces observed along the line of the boundary between the United States and Mexico. By Maj. *W. H. Emory*.

Results of some investigations respecting the double comet of Biela. By Prof. *J. S. Hubbard*, of the National Observatory.

Illustration of cycloidal curvature as involved in the supposititious travelling whirlwinds, and some new demonstrations of the impossibility of storms being whirlwinds, unless on a limited scale, as the consequence of in-blowing winds. By Prof. *Robert Hare*.

Suggestion relative to the observation of the annular eclipse of the sun of May 26, 1854. By *Stephen Alexander*.

On the distribution of temperature in and near the Gulf Stream, off the coast of the United States, from observations made in the Coast Survey. By *A. D. Bache*, Superintendent.

On the Gulf Stream. By Lieut. *M. F. Maury*.

On the Basin of the Atlantic. By Lieut. *M. F. Maury*.

Astronomical determination of the sun's diurnal and annual intensity. By *L. W. Meech*.

On the transparency of the ocean. By Commander *Glynn*, U. S. N.

On the nature of Forces. By Lieut *E. B. Hunt*, Corps of Engineers, U. S. A.

Description of the U. S. Coast Survey Apparatus for measuring base lines. By Lieut. *E. B. Hunt*, U. S. A., and Assist. U. S. C. S.

Note on a new electro-chronometric method. By Dr. *Wolcott Gibbs*.

On a new instrument for facilitating the projection of great circle routes in charts, and finding by inspection the course and distance. By Prof. *W. Chauvenet*.

Comparison of the British Association Catalogue of Stars with the Greenwich Twelve Year Catalogue. By Prof. *Elias Loomis*, University of New York.

Remarkable lunar phenomenon observed at Auburn, N. Y., Feb. 16, 1843; with diagram. By *Blanchard Fosgate*, M.D.

On the arrangement of Lecture rooms, with reference to sound and sight. By Prof. *Joseph Henry*, Secretary Smithsonian Institution, Washington.

A constructive method of projecting solar eclipses. By *Chauncey Wright*, Cambridge, Mass. Presented by Lt. C. H. Davis, U. S. N.

On the superior facilities for the computation of the Lunar Ephemeris afforded by the new system of arguments introduced by Prof. Peirce into his "*Tables of the Moon.*" By *J. D. Runkle.*

On Irradiation. By Prof. *W. B. Rogers.*

On the Satellites of Uranus. By Prof. *Elias Loomis*, University of New York.

On the inverted microscope; with some remarks on the illumination of microscopical objects. By Prof. *J. Lawrence Smith*, of Louisville, Ky.

The astronomical expedition to Chili. By Lieut. *J. M. Gilliss*, U. S. N.

Abstract of a paper on the tidal currents of Long Island and approaches, from observations in connection with the United States Coast Survey. By *Charles A. Schott.*

On the longitude of Frontera, El Paso, and San Eleazario, resulting in the determination of a cardinal point of the Boundary Survey. By Maj. *W. H. Emory.*

On the relative value of the different astronomical methods of determining the longitude. By Lieut. *C. H. Davis*, U. S. N.

On the determination of the longitude of the Observatory at Cambridge from the chronometric expeditions of the Coast Survey. By *G. P. Bond.*

Difference of longitude by Moon and Star culminations. By Prof. *G. W. Coaklay.*

The longitude of America; determined by moon culminations. By Prof. *B. Peirce*, of Harvard College.

Method of observing at sea for the determination of the latitude, longitude, and variations of the compass. By *O. C. Badger*, U. S. N.

Cloverden Observatory and the Shelby College (Kentucky) Equatorial. By *B. A. Gould*, Jr., and *Joseph Winlock.*

(2.) *Meteorology.*

The Brandon tornado, Ohio, January 20, 1854. By Prof. *O. N. Stoddard*, Miami University.

Cape Verde and Hatteras hurricane and other storms. By *W. C. Redfield*, of New York.

On the probable increase of hail storms in Cuba, especially from 1844 to 1854. By *Andres Poey*, of Havanna.

An account of a storm that passed over Connecticut, August 1, 1851. By Prof. *John Brocklesby.*

On the meteorological phenomena observed at various points on the Boundary Survey. By *Marine T. W. Chandler* (read by Maj. W. H. Emory).

On the barometer off Cape Horn. By Lieut. *M. F. Maury.*

A Theory of Storms. By *T. Basnett.*

On the permanence of the principal conditions of climate. By *Lorin Blodget*, of Washington.

The climate of Chili. By Lieut. *J. M. Gilliss.*

On the swelling of springs and the re-appearance of storms before rain. By Prof. *John Brocklesby.*

The Meteorograph: a self-registering instrument for meteorological observations. By Prof. *N. B. Webster*, of the Virginia Collegiate Institute, Portsmouth, Va.

On the law of variations of atmospheric pressure through successive months of the year; and its practical application to barometric measurements of heights in the interior of Continents. By *Lorin Blodget.*

(3.) *Geology and Mineralogy.*

On the cleavage and other effects caused by trap dykes in the middle secondary rocks of Virginia. By Prof. *W. B. Rogers.*

Notice of a peculiar variety of coal from Breckenridge county, Ky. By Prof. *B. Silliman*, Jr.

On a number of mineral species. By *T. S. Hunt*, of the geological survey of Canada.

Notice of some imprints which have recently been observed in the sandstone strata at the quarries in Portland, Ct., with some remarks on this formation on the Atlantic coast of the United States. By *John Johnston*, Prof. Nat. Science Wesleyan University, Middletown, Conn.

Brief outline or general description of a remarkable fossil, not known to be described, and by some supposed to be an Ichthyodorulite. By Prof. *Wm. Hopkins*, of Genesee College, Lima, N. Y.

On the absence of the evidence of remains of fishes in all the Silurian rocks of the United States. By *James Hall.*

Is anthracite the coke of bituminous coal? By Prof. *B. Silliman*, Jr.

On phosphatic organic remains in the Palæozoic rocks. By *T. S. Hunt*, of the Geological Survey of Canada.

On the Crystalline Limestone of North America. By *T. S. Hunt*, of the Geological Survey of Canada.

Remarks upon the geological formation of the country along the line of the boundary survey, based upon the examination of Dr. Parry, made under the order of Major Emory. By *James Hall.*

On the western limits of the Cretaceous formation on the northern continent of America, as evidenced by the various collections that have been made by exploring expeditions under the direction of the government of the United States. By *James Hall.*

Geology of the lead mines of Wisconsin. By *Edward Daniels*, Geologist to the State of Wisconsin.

On the age of the so-called new red sandstone of the United States. By Prof. *W. B. Rogers.*

Red sandstone of the Connecticut River Valley, and the proofs of its Oolitic or Liassic age. By *James Hall.*

A description of a post-diluvial deposit in Campbell Co., Ky., with a catalogue of the fossil remains. By *W. H. B. Thomas*, of Cincinnati, Ohio.

Sketch of the general geological structure of the region of country in connection with the United States and Mexican boundary line. By *C. C. Parry.*

On the chemical composition and metamorphoses of some sedimentary rocks. By *T. S. Hunt*, of the Geol. Survey of Canada.

Some comparative observations on the carboniferous strata of North America. By Prof. *H. D. Rogers.*

On some phenomena of cleavage structure, and metamorphism in coal and other strata. By Prof. *H. D. Rogers.*

On the geology of the Lower Rio Bravo. By *Arthur Schott* (read by Maj. W. H. Emory).

The Silurian and Devonian systems; and the nature of the evidence for drawing a line of separation between the two systems in the United States. By *James Hall.*

Observations upon the geology of the Mauvaises Terres, Nebraska, with notices of the geographical and geological range of some of the fossils of that region. By *James Hall.*

Remarks upon a collection of Cretaceous fossils from Nebraska, and the absence of species known in the southern extension of the same formation. By *James Hall.*

Remarks upon the results of extensive and continued collections of fossil species from a portion of the Silurian rocks of New York, showing the number of species and individuals of each species obtained from a limited locality during a period of ten years. By *James Hall.*

On the reproduction of similar types or representative species in successive geological formations. Illustrated by a collection of species of the Brachiopoda from the Niagara and Lower Helderberg groups of the Palæozoic rocks of the United States. By *James Hall.*

(4.) *Chemistry.*

On the use of hydrogen gas to displace sulphuretted hydrogen in the analysis of mineral waters. By Profs. *W. B. Rogers* and *R. E. Rogers.*

Illustrations of chemical homologies. By *T. S. Hunt*, of the geological survey of Canada.

Decomposition of water at the ordinary temperature, by an alloy of zinc and antimony; with a description of a new process for procuring hydrogen. By *Josiah P. Cooke*, Jr.

A new filtering apparatus. By *Josiah P. Cooke*, Jr.

On a new form of electrical machine. By *G. C. Schaeffer.*

Researches on arseniuretted and antimoniuretted hydrogen, and their relations to Toxicology. By Prof. *Raphael Napoli*, of Naples.

On the chemical relations of odors, and their employment as tests. By *Geo. C. Schaeffer.*

On meteoric stones; with an account of some recently discovered. By Prof. *J. Lawrence Smith*, of Louisville, Ky.

On two new general methods of chemical analysis. By Dr. *Wolcott Gibbs.*

On the volumetric determination of Nitric, Arsenic, Antimonic and Stannic acids, and on the separation of Manganese, Cobalt and Nickel. By Dr. *Wolcott Gibbs.*

The American Patent System, and its relations to science—especially to chemical science. By Dr. *L. D. Gale*, of the Patent Office, Washington.

(5.) *Zoology.*

Life in its physical aspects. By *Charles Girard.*

On the Delphinus, or Phocæna Orca, the Whale Killer or Thresher, mentioned by John Tradescant in the journal of his voyage to Russia in 1618. Communicated by Dr. *Hamel*, of the Imperial Academy of Sciences at St. Petersburgh.

Experimental observations on the sense of smell and taste. By Dr. *H. C. Hilgard.*

On the development of monocotyledonous stems. By *J. Darby*, of Georgia.

On the Whale. By Lieut. *Maury*, U. S. N.

Appendix.—On Personal Equation, &c. By *J. Winlock.*

Some reasons for suspecting the Mobilian language to have been spoken along the southeastern shores of North America in the first half of the 16th century. By *Buckingham Smith.*

2. *Abstract of a Meteorological Journal kept at Beloit College, Beloit, Wis., for the year* 1853, (communicated for this Journal.—Lat. 42° 30′ 23″ N.; Long. 12° 03′ 20″ W. from Washington; elevation above Lake Michigan, 172 feet—above the Ocean, 750 feet; by S. P. Lathrop, M.D., Professor of Chemistry and Natural History.

Months.	Barometer.			Thermometer.			Cloudiness.	Prevailing winds.	Inches rain & melted snow.
	Max.	Min.	Mean.	Max.	Min.	Mean			
January,	29·65	28·44	29·635	48	− 5	27·04	3·70	N., S. & S.W.	1·25
February,	29·61	28·66	29·193	50	− 9	23·00	4·55	N.W. & N.	2·85
March,	29·64	28·69	29·198	60	0	33·57	3·48	N.W., N. & S.	2·00
April,	29·56	28·58	29·147	70	27	40·12	4·82	N.E. & N.	5·68
May,	29·59	28·80	29·295	84	38	57·44	4·54	N.E., N.W. & S.	4·37
June,	29·53	28·92	29·377	91	54	73·16	3·04	S.W. & S.	4·85
July,	29·52	29·04	29·343	83	54	68·90	2·78	S.W & N.E.	8·10
August,	29·55	29·08	29·238	91	52	71·37	3·08	S.W. & N.W.	1·68
September,	29·53	28·78	29·234	91	41	64·02	3·97	S.E. & N.W.	6·48
October,	29·58	28·78	29·431	73	11	47·00	2·65	S., S.W. & N.	·50
November,	29·77	28·91	29·347	61	10	41·30	6·02	S.W. & N.	6·85
December,	29·59	28·53	29·156	53	− 5	26·39	3·83	S.W. & N.W.	1·10
Year.	29·77	28·44	29·308	91	− 9	47·75	3·87	S.W., N.W. & N.	45·71

The mean temperature of the past year is 47°·75, being nearly the mean of the three previous years, which is 47°·505.

The mean temperature for the winter months of 1852–53 is 24°·863, which is something over a degree less than the mean of the two previous years, and 2°·567 lower than for the year 1850–51. The mean temperature for the spring months is 43°·71, being nearly as low as the temperature of the same months in 1850, which was 43°·08, and 2°·713 lower than the mean of 1851 and 1852. The mean temperature of the summer months is 71°·143, being nearly the same as in the year 1850, and 1°·24 higher than the mean of the years 1850–52. The mean temperature of the autumnal months is 50°·773 being about the same as the year 1851, and 1°·38 above the mean of the years 1850–52.

The average density of the atmosphere as indicated by the barometer, is 29·308 inches, being ·031 inch below the year 1851, and nearly ·04 higher than either of the years 1850 and 1852.

The amount of rain and melted snow for the year is 45·91, which is 5·91 more than the previous year, and 7·66 less than the mean of the two years 1850–51. This was not so equally distributed through the several months of the year as usual, the month of July having 8·10 inches, while the month of October had only 0·50 inch. September and November have nearly the same amount.

The amount of snow which fell in the winter of 1852–53 is 30 inches, being the same amount as last year, and more than either of the two previous years, and it was quite equally distributed through the winter months.

The last year was never surpassed by more abundant crops. They were *uniformly* good. None of them were injured to any amount, by any unfavorable condition of weather, or superabundance of insects injurious to vegetation, or blight or mildew. Fruit trees of every kind and description were loaded to their utmost with delicious fruit. We fear that we shall seldom see the like of the past year in the quantity and quality of grains, and the richness and abundance of fruit.

The prevailing winds were Southwest and Northwest, instead of N. and N. W., as in the three previous years.

Calendar.—*February* 8th, Coldest day of the year, average of thermometer –3°; 28th, Dwarf Peony and Star of Bethlehem up.

March 7th, Auroral arch; 15th, Remarkable Parhelia at 3 P. M.; 17th, Tulips, first birds heard to sing, wild geese seen; 19th, Bluebirds, Blackbirds and Woodcock seen; 22d, Narcissus up, Robins seen; 24th, Larkspur up; 26th, Triton seen.

April 4th, Pulsatilla potens and Ranunculus fascicularis in flower, striped snake seen; 14th, Gooseberries in leaf; 16th, Missouri and black Currant in leaf, Cucullaria in flower; 17th, commenced gardening; 25th, Jonquil in blossom; 26th, Dwarf Iris in bloom, Turtles, Frogs and Toads seen.

May 2d, Missouri currant in flower; 4th, Plum in blossom; 5th, Cherry in blossom; 11th, Puccoon and Liverwort in flower; 12th, Baltimore Oriole and Turtle Dove seen; 13th, Uvalaria perfoliata in flower; 16th, Silphium trifoliatum, Greek Valerian, Blue Phlox, American Cowslip and Tulip in flower, burr and black Oak in leaf; 17th, Robinia hispida and Carya alba in leaf; 19th, Lilac and Cowslip in flower, corn planting; 21st, Trillium and Stramonium in flower; 22d, Blue eyed grass and Hypoxis erecta in flower; 25th, first really growing weather, cold hitherto; 28th, Mountain ash, Baptisia tinctoria, Creeping vetch and Potentilla in flower; 30th, Zizia and Aquilegia in flower.

June 2d, Vibernum opulus, Cinnamon rose, Arenaria laterifolia, and Pentalophus longiflorus in flower; 6th, Capsella bursapastoris, Cypripedium spectabile, Ranunculus aquatilis, Philadelphus coronarius and Hydrophyllum virginicum in flower; 9th, Philadelphus flava and Iris versicolor in flower; 18th, Campanulas, Lobelias and Rudbeckias in flower.

July 13th, Auroral arch and streamers.

August 11th, Hottest day, average of thermometer 85°·33; 23d, Comet first seen in the west at 8¾ P. M.

September 1st, Auroral arch.

October 25th, First snow.

3. *The Climate of San Francisco—Review of the Weather for the Year* 1853; by Dr. HENRY GIBBONS.—The first part of January was cloudy and rainy, but after the 11th, the weather was mostly clear and charming, only one rain occurring in the last two weeks. The lowest temperature was 41°, and the highest 62°. The mean at sunrise was 47½° and at noon 56½°. The prevailing winds were very light, from north and northwest. There were nine days entirely clear, and four days entirely cloudy. January 1852, was colder, having five mornings below 41°; January 1851, was much colder, having 13 mornings below that point. Both these months were dry, scarcely any rain falling. But the first two weeks of January 1852, were rainy; the remainder of the month dry. Sacramento City was drowned on the 1st of the month. In January 1851, there was ¾ inch of rain; in 1852, ½ inch; and in 1853, 4 inches.

February; for the first three weeks, the weather was fine. Up to the 21st there were no less than seventeen days entirely clear. In the last week there were four rainy days, but in the whole month only one day was entirely cloudy. The temperature was delightful, the means at sunrise and noon being 48° and 60°. The coldest morning 42°, and the warmest noon 67°. The prevailing winds were from north, northwest and west, and mostly light. The hills were covered with flowers. In February 1852, there were four mornings colder than in this month, and in 1851, thirteen colder mornings. February appears to be always a dry month. In 1851, there was ⅓ inch of rain; in 1852, ½ inch; in 1853, 1 inch.

March was mostly a pleasant month, with several moderate rains towards the middle, and three days of heavy rain in the last week. The prevailing winds were from West, Northwest and North, with an increasing tendency to West, and increasing force. The minimum temperature was 41°, and the maximum 77°; mean at sunrise 49½°, and at noon 62°. The first week of the month was very warm. On the 15th, Mount Diabolo was covered with snow, as mostly happens towards the end of March. There is commonly considerable rain in this month. In the dry winter of 1851, there were 2 inches; in 1852, 6½ inches; in 1853, 5 inches.

April was a pleasant month, with winds generally from West and Northwest, and frequent light sea breezes. Temperature agreeable, varying from 46° to 56° at sunrise, and from 59° to 75° at noon; means at sunrise and noon 52° and 65°. The heaviest rain for several years fell on the night of the 16th, viz: upwards of three inches in twelve hours. The only thunder of the season occurred during this rain. April mostly gives us some days of rainy weather. In 1851, an inch of rain fell; in 1852, only ¼ inch; in 1853, 5 inches. The coldest morning was 46°. In 1851, there were five colder mornings, and in 1852, eighteen. Dry and cold weather go together in our winters.

May was generally warm and pleasant, the coldest morning being 47° and the warmest 62°, while the coldest noon was 61° and the

warmest 81°. The means at sunrise and noon were 53½° and 68°. The wind settled in the western quarter, and increased in force, though not offensively high. There were several slight rains, with a large portion of cloudy and broken weather. The clouds always give their parting blessing in May. In 1851, there fell ¾ inch of rain; in 1852, ⅓ inch; and in 1853 ⅓ inch.

June was uncommonly warm, the mercury ranging from 49° to 60° at sunrise, and from 60° to 84° at noon. The sea winds were constant, but not often fraught with mist. The sky was unusually clear for summer.

The weather of July was uniform, varying in temperature at sunrise from 50° to 55°, and at noon from 63° to 78°. The means at sunrise and noon were 52½° and 68°. Cloudy and misty weather prevailed and there were but four days of clear sky from sunrise to sunset.

August was a cloudy and misty month, but less so than July. Its temperature also was very uniform, ranging at sunrise from 51° to 56°, and at noon from 63° to 76°. The means at sunrise and noon were 53° and 67°. The sea winds, though constant, were not often high.

In the three summer months of 1851, there were four misty mornings, and 33 misty evenings; in 1852, 7 mornings and 27 evenings, and in 1853, 15 mornings and 36 evenings, misty.

September was rather pleasant, affording one or two days really hot. The morning extremes were 50° and 60°, and the noon extremes 63° and 88°. The sea winds continued their daily visits with diminished force, and there was much cloudy and broken weather, with two small rains near the middle of the month. The means at sunrise and noon were 55° and 70°. September usually brings a day or two of light rain. One inch fell in 1851, a few drops only in 1852, and an eighth of an inch in 1853.

October was as usual, warmer than several of the previous months. The coldest morning was 49°, and the warmest 64°; the coldest noon, 60°, and the warmest 85°. The means at sunrise and noon were 54¼° and 71°. During this month, the sea winds began to give out. The sky was was generally fair, and one slight rain fell, amounting to $\frac{1}{10}$ inch. In October, 1851, there was $\frac{2}{10}$ inch, and in 1852, ¾ inch.

November placed the usual embargo on the sea winds. The temperature was moderate, a few slight frosts occurring. The coldest morning was 44°, and the warmest 59°; the coldest noon 55°, and the warmest 73°. The means at sunrise and noon were 51° and 63°. There was much cloudy weather, with occasional moderate rains. The prevailing winds were from west and south. The first southeasterly storm, in 1851, was on the 8th; in 1852, on the 13th; and in 1853, on the 16th. Quantity of rain in the three years respectively, 2 inches, 5½ inches, and 1½ inches.

December was more pleasant than common. The coldest morning was 40°, and the warmest 54°; the coldest noon 50°, and the warmest 69°. The means at sunrise and noon were 46½° and 57½. Hoar frosts were frequent, but the cold was not sufficient to injure vegetation. There was much fair weather. A copious rain fell on the 10th, and several light rains at other times. Prevailing winds from north, northwest, northeast and south. Thunder was heard on the 10th, for the

second time in the year. In December 1850, there fell 1 inch of rain; in 1851, 7 inches; in 1852, 12 inches—the greatest quantity in any one month for three years and more; in 1853, 2 inches.

The summing up for the year 1853 exhibits a mean temperature of 51⅓° at sunrise, and 65° at noon, which is warmer by two degrees than either 1851 or 1852. The lowest mark reached by the mercury was 40°, or eight degrees above the freezing point. The extreme of heat was 88°. In 1852, the extremes were 35° and 98°; in 1851, 30° and 84°; and in December 1850, the thermometer fell as low as 28°. The amount of rain in each month of 1853, was, in round numbers, as follows: January, on eight days, 4 inches; February, four days, 1 inch; March, six days, 5 inches; April, eight days, 5 inches; May, three days, ⅓ inch; June, July and August, none; September, two days, ⅛ inch; October, one day, $\frac{1}{10}$ inch; November, eight days, 1½ inches; December, six days, 2 inches; making in the year, forty-four days on which rain fell, to the depth of 19 inches. In 1851, there was rain on fifty-three days, quantity 15 inches; in 1852, on sixty days, quantity 25½ inches. From the 1st of January, 1853, to the dry season, the quantity was 16½ inches; and from the dry season to the end of the year, 3½ inches. The last rain of the Spring was May 24th, and the first of the Autumn was September 15th. The hills began to look green in the last week of November, and at the close of the year at least thirty species of plants were in bloom around the city, some of them the lingering flowers of Summer, and a few the products of a new growth. There were two small specimens of thunder during the year, none of the aurora borealis, and a considerable sprinkling of meteors in the second week of August, and also in the fourth week of November.

4. *Mammoth Trees of California.*—An article in the Sonora Herald of August 27, 1853, contains the following statements respecting the Mammoth Trees of California, one of which was the subject of Prof. Gray's remarks in the last volume of this Journal. The tree that has been cut down was 95 feet in circumference at the ground, and 300 feet high. Another tree is lying near by, now dead. It is decayed within, and contains a cavity which for 250 feet of its length averages 10 or 12 feet in height; so that a man may enter it on horseback and ride the whole distance. From its diameter near its base, its circumference was estimated at 110 feet, and it was judged to have been near 400 feet high. Another tree still standing has a circumference near the ground of 97 feet, its height 350 feet. Not far distant there is a trio of trees, the united circumference 92 feet, and height 300, the middle one rising 200 feet without a branch. In the same neighborhood there is a twin tree, with a circumference of 90 feet; the trunks of the two parts are joined for 10 feet; the height is 325 feet. A single tree of perfect symmetry, is 92 feet in circumference and 350 feet high. There are 85 of these mammoth trees scattered over an area of 50 acres. The soil of this Mammoth Grove is moist and rich.

On the route from Sonora to the Grove, about 10 miles northward of Sonora, there are the "Natural Bridges" over the Cayote Creek, four miles below Vallecita. The rock is limestone. The entrance of the arch under the upper bridge is 25 feet wide and 30 feet high, and the

rock is variously eroded into Gothic forms and hung with stalactites. The lower bridge is of equal extent, though differing in imitating more the rounded Grecian style, than the Gothic, in its arches.

Fifteen miles north of Vallecita is Murphy's camp, and 15 miles beyond, the traveller arrives at the Mammoth Grove. Four miles before reaching it, he has the Sierra Nevada in view, bounding the horizon on the north and east, high hills between the Sugar-pine and Tuolumne on the southeast, Bald Mountain on the south, and the Bear Mountain range on the west; and the country is a mass of precipitous hills and deep recesses or shaded ravines. Nine miles north of Murphy's there is an extensive cave with many apartments.

5. *Recent Earthquake Shocks in California*, (from letters of W. P. Blake, dated San Francisco, and addressed to one of the editors.)—A slight shock of an earthquake was felt in this city by many persons on the morning of March 2d. I was sleeping with my head towards the east, and my couch seemed to have received a violent push from that direction; the windows and doors rattled at the same time. Although I had never before experienced the sensation of an earthquake, I was so strongly convinced that I had been awakened by one, that I arose and carefully noted the time ($4^h\ 40^m$ A. M.). A friend who occupies a room near mine, and was lying north and south, felt the movement, and describes it as transverse to the direction of his bed. The motion was evidently very rapid, but not sufficiently extensive or violent to leave any traces of its passage.

A similar shock was felt here in January last, at 3 o'clock on the morning of the 9th. And on the third of the same month, two successive shocks were reported at Mariposa. The last steamer that arrived from Rejou, brought the intelligence that clouds of smoke and ashes were constantly rising from the crater of Mount St. Helens. It is said that the smoke issues in sudden puffs.

Earthquakes are so common all along this coast, that it becomes important to have at different points suitable instruments for recording the direction and intensity of the waves.

Another earthquake was felt in this city on the 10th of April, at 10^h 38^m A. M. It was very generally felt throughout the city. It is also stated that it was so violent at Point Lobos that glass in some of the windows was broken by the jar. The motion of the earth appeared to be in a vertical rather than a horizontal direction, producing a sensation of rising and sinking, as if a heavy body had fallen upon an elastic floor. The vibrations were short and sharp, apparently as if formed by an explosion. Two shocks were noticed, with an interval of five or six seconds between them.

6. *Memorial to the United States Congress by a Special Committee of the American Association for the Advancement of Science, on establishing a Geographical Department of the Library of Congress.*

At the meeting of the American Association for the Advancement of Science, held at Cleveland during August, 1853, a resolution was submitted providing for a special committee to prepare and present a Memorial urging on Congress "the advantages of establishing a complete, thoroughly organized, and liberally sustained Geographical Department of the Congress Library, and presenting therein such a project or plan

of organizing this Department as shall seem to the Committee best adapted to promote its final usefulness and success in relation both to the Government and to the country at large." The undersigned members of this Committee, in execution of the duty thus imposed, would now respectfully offer such views on this subject as seem most appropriate.

I. There is not in the United States, or on this continent a single collection of geographical materials which is even tolerably complete. The Harvard collection, the collection of the State Department, the Hydrographic Office, the Topographical and Engineer Bureaus, the Coast Survey, the Smithsonian Institution, and those of Libraries, Colleges, Societies and scholars generally, throughout our country, have been formed for some special and limited purpose, and hence, all are practical and imperfect. None rises to the rank of a true Geographical Library, in which should be found the means of investigating all geographical questions, both of sea and land, at home and abroad. Year by year partial localities assume the highest temporary importance; as for instance, quite recently, Hungary, the Black Sea, Japan, China, Australia, the Pacific Islands, Central America, our entire western coast, the Amazon, the La Plata, and especially our unexplored Western Territories. None can say how great the value of local information on any country, either old or new, may become in a single year. Yet, there is not on this continent any single place where we can resort with confidence for the materials requisite for precise and complete investigation on such questions, as they arise. Publications have actually been made which amply illustrate most great questions of Commerce, policy, international relations, military operations, and Science, so far as they depend on Geography; but these publications have only been systematically collected in some of the great libraries of the European capitals. Hence, we are forced to seek across the Atlantic, the means of thorough investigation into many of the important questions influenced by geographical considerations, or unquestioningly to accept the information vouchsafed by foreign investigators, by whatever prejudices or designs their views may be affected. For instance, would we follow critically the military operations between Turkey and Russia: there are not to be found in this country the geographical aids requisite for a strategic insight into the present and coming campaigns. In the French *Dépôt de la Guerre*, on the contrary, we would be able to trace each step and probability, because the French Government has been systematically collecting, through many years, all possible information on this, as on all other supposable theatres of war or policy. It is a singular and striking fact that the most extensive collection of maps now in America, even in the American department was collected by Prof. Ebeling of Hamburg, and that this collection, purchased by Mr. Thorndike of Boston, and by him presented to the Harvard Library, has been laid under serious contribution for some of our most important negotiations, especially that on the Northeastern Boundary question. Not only is there among us a signal deficiency of collections on foreign geography, but there is at best only a most imperfect and fragmentary centralization of materials illustrating the past and present geography of the states, counties, towns, cities and historical localities of the Uni-

ted States. In brief, while there are sundry partial and special collections of great value owned by scholars, societies, and the General and State Governments, there is nowhere a real and general library of Geography in the United States. Hence we consider the formation of a systematic, comprehensive and complete geographical library, as a most genuine and unequivocal *American desideratum.*

II. The materials which an American National Library of Geography should embrace may be distributed under the following classes:—1st, United States Maps, including general, state, county, town, city and village maps, and plans of historical localities; embracing not only published maps, but manuscripts or tracings of valuable unpublished surveys. 2d, United States Charts, including DES BARRE's and other early surveys, the surveys of our coast, rivers and harbors by the Engineer and Topographical Bureaus, and the coast survey, the topographical lake survey, and all municipal and private charts of importance along our entire seaboard, as BLUNT's, for instance. 3d, Foreign Maps, including the detailed Topographical Maps prepared by the several European States, such as those made by the Ordnance, French, Swiss, German, Prussian, Italian, Austrian, Russian, Swedish, Hindostan, Canadian and Cuban Surveys. Also all maps of the West Indies, of Central and South America, of the British Provinces, (including Hudson's Bay Company Maps,) the Russian Possessions, the Pacific Islands, and, indeed, *all* valuable maps of foreign domains, whether of public or private origin. 4th, Foreign and Ocean Charts, including the 2,000 British Admiralty Charts, the 1,400 charts of the French *Dépôt de la Marine*, the Spanish, Prussian, and Swedish charts, the great variety of private and Expedition charts, MAURY's wind and current charts, &c. 5th, The publications of Exploring Expeditions—especially the works of the British, French, Russian, Austrian, Spanish, and American Governmental Expeditions; as also reports of private voyages and travels of reputation. Peculiar importance should be attached to publications illustrating the early discoveries and explorations of the American continent; to subsequent explorations of our coast and interior, and the Polar, Central and South American voyages and travels. 6th, Geographical Society publications and periodicals, such as those of the Royal Geographical Society, of London; the Bombay Geographical Society; the Asiatic Researches; the Paris *Société de Géographie;* and the Russian Geographical Society; with the *Nautical Magazine*, and other similar periodicals. Also, all pamphlets on geograpical subjects should be collected with especial industry and care. 7th, Books illustrating local geography—especially within the United States; topographical descriptions; hand-books, town and city annals, and whatever can illustrate our geography in relation to history, should be collected; and the same to some extent for foreign countries. 8th, Books and maps on Physical Geography. 9th, Special atlases of cities and states—such as those of VAN DER MAELEN, JOHNSON, the Society for the Diffusion of Useful Knowledge, COLTON, &c. BAUERKELLER's series of maps in relief should be added. 10th, Works on Geodesy and Navigation, and descriptions of geodetic surveys. 11th, Works on Geographical Bibliography. 12th, A pair of first-class terrestrial and celestial globes.

It is only by great industry and skill in collecting these materials that a geographical library of the first order can be formed at all, and even then completeness can be obtained only after some years of vigorous and liberally sustained effort. The Library of the *Dépôt de la Marine* for instance, includes over 4,000 distinct works of geography, many of which extend to several volumes; besides which there is a vast collection of separate maps and charts. Such a repository can be formed only by collecting through a long series of years; though that portion which is of the greatest immediate importance, can fortunately be accumulated in a comparatively short period.

III. * * *

A Geographical Library of Congress would possess an important advantage in that prestige of name and position which would enable it to enlist, if well administered, the friendly cooperation of foreign representatives, and through them of the proper departments of their respective governments. As many of the most important geographical works have been official or governmental publications, this cooperation is actually essential to the completion of such a collection as that proposed.

A geographical library of Congress would furnish invaluable aid to the coordinate executive branches of Government, and would be a judicious and well-requited enterprise, were it only for the services it would render to the State Department, the Engineer and Topographical Bureaus, the Coast Survey, and the various Naval Bureaus. Its value in relation to river and harbor improvements, to local and general American history, to map compilations for Government and common use, to the intelligent discussion by the periodical press of important pending questions; its agency in fostering and giving a right direction to contemplated explorations, in making known the researches of foreign explorers, and in indicating what geographical researches are most essential or most worthy of patronage; these and many other prospective uses might be urged as reasons why the general government should execute this project for the benefit and in behalf of this nation.

IV. A geographical library can be formed and duly administered only by being placed under the special direction of one versed in geography as a science. In this respect it differs much from any other section of a general library. The materials to be accumulated must be procured from sources so diverse and special, that a general geographer cannot be well informed thereon. Many valuable maps and charts exist only in manuscript, and tracings should be procured and verified. This demands an acquaintance with drawing. An active and laborious correspondence would be necessary to bring together the vast number of local maps which are or will be published on the subdivisions of the United States; also the best foreign maps of cities, provinces, &c. Nor can any one but a geographer of superior capacity, attain that critical knowledge of the character and reliability of different maps and charts, which is the first essential before using them. The system to be employed in storing, arranging and indexing an aggregate of many thousand maps and charts, differs entirely from that pursued in book libraries. The charge of compiling new maps and of tracing copies for the library and for individuals, which would be cardinal features in such a library, is totally foreign to the sphere of a general librarian.

It would be incumbent on the head of this department to maintain correspondence with Geographical Societies, with explorers, and with map publishers, all of which could be done only by a geographer. Moreover, it would be highly desirable that an annual report on the progress of geographical discovery and science should be submitted to Congress for the benefit of all who are interested in this important branch. All care should be exercised in procuring prompt information on such dawning and passing events as involve geographical elements, by corresponding with well informed authorities, by collecting and studying the publications bearing thereon, and by maintaining a complete reference index in as perfect a condition as practicable.

In view of all these facts and considerations, it is evident that the Geographical Department now proposed should have special rooms, a special head, special employés, and a special administration. As a section of the general library, it could by no means be well conducted, for no general librarian living could successfully discharge special duties of the nature proposed. A distinct and coordinate organization and administration seem therefore indispensable to success. Moreover, stability of tenure for the geographical librarian and his assistants, serving as it would to perpetuate the teachings of experience, should be secured and esteemed next only to character, mental vigor, industry, method and capacity for administration. Under the general direction and control of the Joint Library Committee, a geographical section thus organized could soon be made, it is believed, an efficient auxiliary to the great interests of legislation, of commerce and of science.

V. The appropriations which this department would require during the first two or three years, would much exceed those for subsequent years, as they would be chiefly absorbed in the purchase of those geographical publications which are at once procurable. The 2,000 Admiralty charts, the 1,400 French charts, the English, Irish, French, German, Prussian, &c. surveys, the principal atlases, the English, French, Russian, Spanish, American, and other volumes of explorations, the geodetic and nautical works, the gazetteers, encyclopedias, hand-books, &c., the globes, and many other items, should be procured almost at once. For the first year an appropriation of $30,000 appears to be no more than a judicious and efficient beginning would require. For the second and third years, a less amount would suffice, and then the requisite appropriation would but slightly exceed that needed for administration, and for the purchase of the special publications of the year. A languishing and feeble beginning is peculiarly to be deprecated, and a large part of the materials now published can better be procured and made available at once than by delaying through a long term of years. The proposed collection is needed *now*, and every year that is lost will add to the difficulty of completing the portion relating to our early history.

In concluding this memorial, we would respectfully state that the project now advocated is one which can scarcely fail to commend itself to all enlightened minds. Acting as we now do in the name and in behalf of an Association embracing a large portion of the American cultivators of science, we esteem it fortunate that the interests of this Association, of Congress, and of the entire nation, are so harmonious and

even identical on the subject of this memorial. It is, therefore, with gratification and with hopeful confidence that we now commend to the liberality of Congress a project which we believe to be truly advantageous to all and injurious to none.

Respectfully submitted on behalf of the American Association for the Advancement of Science, by A. D. Bache, J. J. Abert, J. G. Totten, A. Guyot, M. F. Maury, Peter Force, Charles Henry Davis, E. B. Hunt.

7. *On Gold and Platinum of Cape Blanco;* by W. P. Blake, (from edit. corresp.)—I have recently procured a sample of the Platinum and Gold washed out from the beach sands at and near Point Oxford (Cape Blanco) on the California coast, near lat. 43° N.

The gold is in small and very thin scales. About 20 per cent. of the sample consists of platinum, also in minute round scales not much larger than grains of common writing-sand. These scales are readily lifted by a magnet, but are not easily separated from the gold. I am informed that the miners throw out as much of the platinum as possible, as it lessens the value of the gold in the San Francisco market. The amount of platinum in the gold as washed out is estimated to vary from 10 to 30 per cent.

8. *Supposed Corallines of the Colorado Desert.*—The supposed corallines observed by Mr. Blake on the borders of the region of the Ancient Lake in the Colorado Desert, are, as he suggests in a recent letter, and as we find on examining his specimens, calcareous incrustations or tufa having singular coral-like forms, resembling some Nullipores.—D.

9. *Additions to Article on Chinese and Aztec Plumagery;* by D. J. Macgowan.—The two popular encyclopedias, referred to on page 59, are the Keh chi king yuen, and the Yuen kien lui yen.

A beautiful article from Shensi is sometimes met with, called *kung tsióh* [peacock] jacket pieces, composed of the skin and feathers covering the head of a species of Pavonidæ, probably the *Polyplectron Tibetanus* of Gmelin and Brisson. Each piece contains about sixteen square feet, and is consequently the covering of many peacocks' heads. Yet they can be had for ten or twelve dollars. The gorgeous garments made out of these feathered skins being less warm than fur, are mostly sought by gay and wealthy ladies, by whom they are worn within doors. The prevailing tints are green and blue, of resplendent metallic lustre; these colors are of varying intensity, mutually changing into each other, or shotted according as the light falls upon them in different directions. Were not the feather garments of the Aztecs made wholly or chiefly like these, of both skins and feathers?

10. *Prof. Edward Forbes.*—Prof. Forbes has been appointed to the vacant chair of Natural History in the University of Edinburgh.

11. *Brazil.*—The eminent Botanist, Martius, has announced his intention of publishing in his general Flora of Brazil a map showing the routes of the most distinguished travellers who have visited that country, and another map giving a general view of its geognostical features.

12. *Obituary.*—Robert Jameson.—Prof. Jameson died in April last at Edinburgh, in his 81st year. He was born at Leith, in 1773. He was for two years a student under Werner at Freyburg, and continued

ever afterward an ardent advocate of the views of his master. Returning from Freyburg in 1804, he was appointed Regius Professor of Natural History in the University of Edinburgh, Lecturer on Mineralogy, and Keeper of the Museum. In 1798, he published on the Mineralogy of the Shetland Isles and the islands of Canary; in 1800, appeared his "Outlines of the Mineralogy of the Scottish Isles;" in 1808 his "System of Mineralogy." In 1819 he commenced in connection with Dr. (now Sir David) Brewster the publication of the Edinburgh Philosophical Journal, after the 10th volume of which he became the sole editor. Prof. Jameson also published various memoirs, and largely promoted the progress of Science by his labors and influence.

13. *Elementary Geology;* by Edward Hitchcock, D.D., LL.D., Pres. Amherst Coll. and Prof. Nat. Theol. and Geol. New edition, revised, enlarged and adapted to the present state of the Science. 418 pp. 12mo, with numerous illustrations.—This work is too well and favorably known to require a detailed notice in this place. It has already reached its twenty-fifth edition. In preparing for this new issue, large additions were made from the stores of facts gathered by laborers in the Science in different countries, besides more than eighty new wood-cut illustrations. The chapter on the operation of aqueous agencies in effecting Geological changes has been entirely re-written, and the author has embodied the results of his own valuable researches on river Terraces and Drift through the New England states and elsewhere. The size and character of the work are especially adapted to class instruction.

14. *Archives de Physiologie de Therapeutique et d'Hygiène*, sous la direction de M. Bouchardat, Prof. d'hygiène à la Faculté de Médecine de Paris. No. 1, Janvier, 1854. Mémoire sur la Digitaline et la Digitale par E. Homolle et T. A. Quevenne. Paris, Germer Bailliere.—This first number of the Archives, extending to 376 pp. 8vo, is occupied with the elaborate memoir of MM. Homolle and Quevenne on Digitaline.

15. *Lectures on Histology*, delivered at the Royal College of Surgeons of England in the session 1851–52, by John Quekett, Resident Conservator of the Mus. Roy. Coll. Surgeons of England and Professor of Histology. Vol. II, Structure of the Skeleton of Plants and Invertebrate Animals. 413 pp. 8vo, with 264 wood-cuts. London, 1854. H. Bailliere.—These lectures treat in a popular way, and in some departments with considerable detail, of the structure of invertebrate animals. The work commences with Sponges, and passes then to the Diatomaceæ, Polythalamia, Zoophytes, Echinodermata, Echini, Mollusca, and Annulata.

16. *Illustrations of the Birds of California, Texas, Oregon, British and Russian America*, intended to contain descriptions and figures of all North American birds not given by former American authors, and a General Synopsis of North American Ornithology, by John Cassin. Philadelphia, Lippincott, Grambo & Co.—No. 3 of this valuable and beautiful work completes to the 96th page. It contains descriptions of Kirtland's Owl (Nyctale Kirtlandiæ), Blanding's Finch (Embernagra Blandingiana), the American House-Finch (Carpodacus familiaris), the Long-tailed Chickadee (Parus septentrionalis), the Red-breasted Teal

(Querquedula cyanoptera), with general observations on the Falconidæ. The plates, of which there are five, are faithfully drawn, and well colored. No. 4 has also appeared, and continues the subject of the Falconidæ. This work is to be completed in 30 parts, each part to contain five plates, and the whole to form two large octavo volumes when completed. Price $1, each part.

17. *Astronomical Observations, made under the direction of* M. F. Maury, *Lieut. U. S. Navy, during the year* 1847, *at the National Observatory, Washington.* Vol. III. Published by authority of the Secretary of the Navy. 4to. Washington, 1853.—Besides the tables of observations made at the National Observatory, this volume contains as appendix A, Observations on Solar Spots made at the Observatory of Georgetown College from Sept. 20, to Nov. 6, 1850, by Prof. B. Sestini, S. J., illustrated by 44 plates: Appendix B. Observations on the Mississippi River at Memphis, Tenn., by R. A. Marr, U.S.N.; in which it is stated that the mean temperature of the river is 60°·95 F., while that of the atmosphere is 60°·44; that the quantity of water passing Memphis per day in March, 1850, varied between 46,138,127,330 cubic feet and 88,827,520,040, the river being 76 to 83 feet deep, and in October, from 10,708,228,080 cubic feet to 16,892,279,100, the least at the close of the month, and the depth of water 52·2 to 56 feet. The silt collected in the river at this time was sent to Ehrenberg, and the Appendix on this subject closes with a Report on the species of infusoria it contained. The whole number of forms observed was 88; and out of 44 polygastrica, no new species were detected excepting a doubtful Gloconema. The high water sediment afforded 65 species, the low water 54. Ehrenberg adds:

"According to my direct investigations, the microscopic organic living part of the river mud, amounts to—

In the Ganges	($\frac{1}{8}$—$\frac{1}{4}$), corresponding	in	each	second	to	69—	139	cub.	ft.
Nile	($\frac{1}{20}$—$\frac{1}{10}$),	"	"	"	"	"	6—	13	"	"
Mississippi	($\frac{1}{50}$—$\frac{1}{33}$),	"	"	"	"	"	2—	4	"	"

"The last is evidently too small and will probably be modified by examination of the finer mud out of the current and near the shore."

The Ganges at high water carries in one second 580,000 cubic feet of water, the Nile 176,148 cubic feet, and according to the data of Marr's tables, the Mississippi carries on an average 434,711 cubic feet.

18. *Field-Book for Railroad Engineers;* containing Formulæ for laying out curves, determining Frog Angles, Levelling, Calculating Earthwork, etc., together with Tables of Radii, Ordinates, Deflections, Long Chords, Magnetic variation, Logarithms, Logarithmic and Natural Sines, Tangents, etc.; by John B. Henck, A.M., Civil Engineer. 244 pp. 12mo. New York, 1854. D. Appleton & Co.—A valuable pocket companion for the practical engineer. It is neatly printed, and put up in pocket-book style, is of convenient size, and in its contents just what a book for the purpose should be.

19. *Annual Report of the Superintendent of the U. S. Coast Survey,* showing the progress of that work during the year 1852. 174 pp. 4to, with numerous charts. Washington, 1853.—The Annual Report of Prof. Bache is one of the most valuable documents issued annually by Congress, and we rejoice to see the volume improved in quality of pa-

per and printing. The plates, which are of great value, now appear in a form convenient for consultation and preservation.

J. Müller: Uber den allgemeinen Plan in der Entwickelung der Echinodermen. 42 pp. 4to, with 8 plates. Berlin, 1853. From the Trans. of the Königl. Akad. der Wissensch. zu Berlin.

Alexander von Humboldt: Kleinere Schriften von A. von Humboldt. Erster Band; Geognostiche und physikalische Erinnerungen, with an atlas containing a view of the volcanoes of the Cordilleras of Quito and Mexico. Stuttgart and Tubingen. 1853. T. G. Cotta.

Carl Vogt: Lehrbuch der Geologie und Petrefactenkunde. 2d edition, in 2 vols. 1st vol. just issued. Bräunschweig, 1854.—An excellent work of unusual beauty in its illustrations.

R. Ludwig: Das Wachsen der Steine oder die Krafte welche die Bildung und Entwickelung der Gebirgsarten vermitteln. 226 pp. 8vo. Darmstadt, 1853.

Adolf Kenngott: Krystallformennetze zum Aufertigen von Krystallmodellen. 2d edition. Vienna, 1854.—This very cheap work is a series of plates containing figures for the construction of models of crystals. The outline of the faces of various crystalline forms is given, and they are so arranged that it is only necessary to cut out the figures from the plates and bend the planes into their places, to make the model; and if the sheets of figures are first pasted on Bristol board, the models will have all the firmness and durability desired.

William Parker Foulke: Discourse in Commemoration of the Founding of the Academy of Natural Sciences of Philadelphia, Delivered March 20, 1854. 58 pp. 8vo. *Philadelphia*, 1854.

A. Davis (Cor. Mem. N. Y. Hist. Soc., &c.): History of New Amsterdam, or New York as it was in the days of the Dutch Governors, together with papers on Events connected with the American Revolution and on Philadelphia in the Times of William Penn. 240 pp. 16mo. *New York*, 1854. R. T. Young.

The American Medical Monthly, Edward H. Parker, M.D., Editor. Vol. I, No. 4, April, 1854. *New York.* G. P. Putnam & Co.—Issued in monthly numbers of 80 pages each. Single copies 25 cts. each.

People's Journal, Alfred E. Beach, Editor. No. 86 Nassau st., New York. Vol. I, No. 6, April, 1854. One dollar a year.—A popular and well illustrated monthly of 32 small quarto pages, treating of the popular or useful arts, with horticulture, agriculture, and whatever is of interest to the farmer, etc. etc.

The Practical Mechanics Journal, Vol. VII, No. 1, May 1854. In monthly numbers of 24 pp. 4to. 25 cts each. *London* and *Glasgow*, W. & J. H. Johnson. *New York*, Stringer & Townsend, 222 Broadway.—A work of real value to the mechanic, able and thorough in its papers, excellent and full in its illustrations. It gives new processes and inventions in chemical arts as well as in manufactures, and also discriminating notices of new publications.

The Merchant's and Banker's Almanac for 1854—published by J. Smith Homans, No. 70 Wall street, New York—contains the Calendar—List of Banks—Banking Directory—Banking Laws, &c. &c.

Proceedings of the Boston Soc. Nat. Hist.—Jan., 1854.—p. 309. On the reproduction of lost parts in Reptiles; *W. I. Burnett.*—p. 311. On Rattle-snakes; *Ib.*—p. 316. On the Cotton worm of the Southern States; *Ib.*—p. 323. On the Sedative action of the poison of the Rattle-snake; *Ib.*—p. 324. List of Birds found both in Europe and America; *T. M. Brewer.*—p. 331. On the zoological nature of Infusoria; *W. I. Burnett.*—p. 353. On a remarkable case of bisexual hermaphroditism; *Ib.*—p. 368. On the nature and character of muscular tissue; *Ib.*—p. 371. On the development of Mollusks in Holothuridæ; *Ib.*—p. 377. Note on the relations of the Fossil elephant of Europe and America; *J. Wyman.*—p. 378. On Fos-

sil footmarks; *E. Hitchcock.*—On the development of viviparous Aphides; *W. I. Burnett.*

Proceedings Acad. Nat. Sci. Philadelphia, Vol. VII, No. 2.—p. 24. Descriptions of new species of Fishes collected in Texas, New Mexico and Sonora; by *S. F. Baird* and *C. Girard.*—p. 29. Rectification of the Generic names of Tertiary Fossil Shells; *T. A. Conrad.*—p. 31. Notes on Shells and descriptions of three recent and one Fossil species; *T. A. Conrad.*—p. 32. Note on the genus Amblychila, Say; *J. L. Le Conte.* (with a plate.)—p. 35. Synopsis of the Species of Platynus and allied genera, inhabiting the United States; *J. L. Le Conte.*—p. 59. Descriptions of new genera and species of North American Frogs; *S. F. Baird.*—p. 62. On Fossil Coniferous wood, from Prince Edward's Island; *J. W. Dawson.*—p. 64. Description of a species of Crane found in Wisconsin; *W. Dudley.*—p 64, 66. Description of Fossil Trees in the coal rocks near Greensburgh, Westmoreland Co., Pa., and fossil fruit, in those of Beaver Co.; *A. T. King.*—p. 66. Descriptions of new Birds of Northern Mexico; *D. N. Couch.*

Proceedings of the American Academy of Arts and Sciences. Boston. Vol. III.—p. 11. On inhaling a fusel-oil compound; *J. Wyman.*—p. 12. On the formation and function of the Allantois; *W. I. Burnett.*—p. 17. On cartilaginous and osseous tissues; *Ib.*—p. 25. On the internal structure of the cranium of the Mastodon.—p. 42. Observations on the family of Cyprinodonts; *L. Agassiz.*—p. 43. On the Signification of Cell-segmentation and the relations of this process to the phenomena of Reproduction; *W. I. Burnett.*—p. 48. Characters of some new genera of Plants, mostly from Polynesia; *A. Gray.*—p. 55. On the development of Aphides; *W. I. Burnett.*—p. 63. Observations on some new species of Cartilaginous fishes; *L. Agassiz.*—p. 65. On a new living Cestracion; *Ib.*—p. 68. Coal region of Deep River, North Carolina; *C. T. Jackson.*—p. 70. On a new filtering apparatus; *J. P. Cooke.*—p. 73. Notices of new species of Mosses from the Pacific islands; *W. S. Sullivant.*—p. 85. On the crystalline form of Arsenic; *J. P. Cooke.*—p. 89. Observations on the Torpedo occidentalis; *J. Wyman.*—On a modification of Ritchie's photometer; *A. A. Hayes.*—p. 94. Observations on a large California Coniferous tree; *A. Gray.*

Journal of the Academy of Natural Sciences of Philadelphia. Second Series, Vol. II, Part IV.

Art. XXVII.—Exotic Fungi from the Schweinitzian Herbarium, principally from Surinam; revised by Rev. *M. J. Berkeley* and *M. A. Curtis,* D.D.

XXVIII.—Descriptions of new species of Unio; by *T. A. Conrad.*

XXIX.—On some new Reptiles from Oregon and the Western Coast of Africa; by *E. Hallowell.*

XXX.—Embryonic Development of Planocera elliptica; *C. Girard.*

XXXI.—On Bathygnathus borealis, an extinct Saurian of the New Red Sandstone of Prince Edward's Island.

XXXII.—Monograph of the Genus Argonauta, Linn., with descriptions of five new species; by *T. A. Conrad.*

XXXIII.—Synopsis of the genera Parapholas and Penicilla; by *T. A. Conrad.*

Annals of the Lyceum of Natural History of New York.—Vol. VI, Nos. 2–4. 1854.

VIII.—On the Homœomorphism of Mineral Species of the Trimetric System; by *James D. Dana.*

IX.—Descriptions of three new species of Pisidium; by *Temple Prime.*

X.—On the Identity of Cyclas elegans, Ad. with Cyclas rhomboidea, Say.

XI.—Catalogue of the Terrestrial and Fluviatile Shells of St. Thomas, W. I.; by *R. J. Shuttleworth.*

XII.—Note on the Geographical Distribution of the Terrestrial Mollusks which inhabit the island of St. Thomas, W. I.; by *T. Bland.*

XIII.—On the Absorption of Parts of the Internal Structure of their shells by the animals of Stoastoma, Lucidella, Trochatella, Helicina, and Proserpina; by *T. Bland.*

XIV.—On Proserpina opalina Ad. and Helix Proserpinula, Pfr.; by *T. Bland.*

XV.—Description of a new species of bird of the genus Larus, Linn.; by *Geo. N. Lawrence.*

XVI.—Descriptions of new Fluviatile Shells of the genus Melania, Lam., from the Western States of North America; by *John G. Anthony.*

XVII.—Descriptions of new species of Shells; by *John H. Redfield.*

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXI.—*On the comparative Expenditure of Heat in different forms of the Air-Engine;* by FREDERICK A. P. BARNARD, Professor of Chemistry and Natural History in the University of Alabama.

IN the year 1840, an air engine of a very simple construction was patented in England by the Rev. Robert Stirling. The effective force in this engine was derived from the fluctuations of pressure created by the sudden alternate heating and cooling of a body of confined air, which was driven from end to end of the containing vessel by the motion of a solid plunger occupying about three quarters of the entire cavity. In its passage, it passed through a regenerator constructed of parallel laminæ of copper; and while one end of the air-vessel was exposed to heat, the other was furnished with a refrigerating apparatus. To the cold end was attached the working cylinder. This engine was successfully operated for several years, at the Dundee iron foundry, and perhaps elsewhere. It was found to be largely more economical than a steam engine, of corresponding power. No advantage, it will be peceived, was taken of compression pumps, to give to the air a higher pressure than that of the reservoir; and, on the other hand, the engine had not the resistance to contend with, which such pumps occasion. The confined air, however, was originally compressed to a great density. In the smaller engines a maximum pressure of 360 lbs. to the square inch was carried—equal to 24 atmospheres—but in the larger ones the pressure rose no

higher than to 240. The maximum temperature usually employed was 650° F.

In examining, in the March No. of this Journal, Mr. Joule's project of an air engine, I assumed, what I think can easily be proved, that the plan there proposed is the most economical of all which have been suggested, and which are at the same time practicable. In Ericsson's, the compression cylinders of Joule, and the regenerators of Stirling, have been united; but I have shown that the regenerators are not essential to economy. It has however, become a matter of interest to compare with each other the several forms which it has been proposed to give to the air engine, in regard to their economical merits; and it is the object of this paper to present the means for making such a comparison.

Ten years ago, the problem here under examination would hardly have admitted of an *a priori* solution. The theoretical and experimental researches of Rankine, Joule, Thompson, Regnault, Clausius, Meyer, and others, have within a recent period, put it within the reach of an easy calculation. I shall assume that it has been established by these authorities:

1st. That when a measurable mechanical effect is produced by heat, a corresponding definite amount of heat ceases any longer to exist as such; and that the measure of this amount has been satifactorily ascertained.* This proposition is convertible.

2d. That when heat is absorbed by a solid or a liquid, it is in part expended in the internal mechanical effect of overcoming cohesion, and in part in the external effect of pressure upon surrounding resistances; while in part it remains sensible: but that, in the case of a perfect gas, there is no internal expenditure; so that all the heat absorbed may be strictly accounted for either in outward work, or in elevation of temperature, or in both.

3d. That consequently, when a gas expands against pressure, but is maintained at the same constant temperature by a just supply of heat, the entire amount of heat so supplied is converted into outward mechanical effect: but that when, during expansion, the temperature rises, more heat is supplied than is so converted; and when it falls, less.

4th. That though no gas is perhaps rigidly perfect, yet atmospheric air, and those aëriform bodies generally, which are not reducible by pressure and cold to the liquid state, are sensibly so.†

5th. That equal volumes of different gases, however different in density or specific heat, when taken at the same pressure and

* Mr. Joule's severe investigation of this point has fixed the "mechanical equivalent" of a "unit of heat"—that is, of the quantity of heat which would raise the temperature of a pound of water one degree F.—at 772 pounds lifted one foot.

† The properties of a perfect gas are expressed in the law of Mariotte, viz: that the pressure is inversely as the volume, temperature being constant; and in that of Gay Lussac, viz: that the pressure is directly as the temperature (above the absolute zero), volume being constant.

temperature and equally expanded by heat under that constant pressure, perform equal quantities of work, and therefore convert into mechanical effect equal quantities of heat.

6th. That equal volumes of different gases, taken at the same pressure and temperature, and maintained during expansion at the same unvarying temperature, convert into mechanical effect different quantities of heat, proportioned to their specific heat estimated according to volume.

7th. That different gases expanding against pressure, without any accession of heat from without, convert into mechanical effect a portion of the heat which they previously held sensibly, the temperature at the same time falling; and that this depression of temperature is the more rapid in proportion as the specific heat of the gas is less. This proposition and the last are convertible.

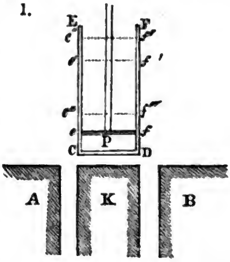
These propositions, with the aid of the specific heats of the gases furnished by Regnault, and of the formulæ of Poisson for the effect upon pressure and temperature produced by change of volume without any transfer of heat to or from the gas undergoing change, furnish all the data necessary for computing the power of any species of engine driven by the elastic force of heated gas.

It may be observed, in the first place, that the differential pressure which constitutes the driving force of an air engine may be obtained in either of two ways: first, by employing a condensing apparatus, worked by the engine itself, to compress a given mass of air, and then to sustain for a time the pressure thus secured, by application of heat; or, secondly, to subject a similar mass of air, confined in a tight vessel, simply to large alternations of temperature, without employing any auxiliary contrivance for compression. In some projects, a resort to both these expedients is aimed at; but in general one or the other will give a distinctive character to the engine.

Some projected air-engines propose to draw a fresh supply from the atmosphere at every stroke, and to discharge it when the stroke is completed; while others are designed to employ the same mass of air over and over again. In discussions of the relative advantages possessed by these different forms of construction, this difference is unimportant. We may suppose, in every case, that the mass of air is constantly unchanged; for in those in which a discharge takes place, we may suppose the discharge to be directly from the working to the supply cylinder, provided we suppose the air to be so effectually refrigerated on its way, that it shall encounter no greater resistance than that which the atmosphere itself would oppose to its free discharge. This being premised, we shall simplify the theory of the air engine, by supposing that all the fluctuations of temperature and pressure which the air undergoes, take place within the working cylinder itself. The fol-

lowing illustration is from Carnot, by whom the first attempt was made, in 1824, to present a dynamic theory of heat.*

1.



Let A be a body constantly at the temperature S°, and capable of preserving another body in contact with it at the same temperature. Let B be a second body, at the lower constant temperature T°, and capable, in like manner, of preserving another body in contact with it at the same temperature. Let CDEF be a cylinder in which moves an air-tight piston P; both cylinder and piston being impervious to heat, with the exception that the bottom, C D, of the cylinder is a perfect conductor, and without capacity for heat. K represents a stand, impervious to heat, designed, when necessary, to neutralize the conducting power of C D.

If this cylinder contain beneath the piston P, in its present position, a gas, or liquid capable of conversion into vapor, and be placed upon the body A, the piston is to be supposed to rise, while the confined gas, or liquid and vapor, is kept at the temperature S°, by the body A. If now we force down the piston to its original position, the body A being supposed to withdraw heat as it before imparted it, and always to maintain the temperature of the gas at S°, we shall have to expend precisely as much force as was developed during the expansion. But if, when the piston has reached the top of the cylinder, we remove the whole to the body B, and suppose the temperature to be instantly reduced by this body to T°, and afterward maintained at that point, then we may force down the piston with less labor than before. Thus the rising of a piston in a cylinder standing on A may force down one in another equal cylinder on B, and preserve an excess of power to be applied to other purposes.

It is practically difficult, if not impossible, by mere refrigerating contrivances, to reduce the temperature of a body of gas or vapor within such a cylinder, with sufficient rapidity or sufficient economy, to render eligible that mode of obtaining a reduction of pressure. But if we suppose the cylinder to be removed from A when the piston has reached a position short of the top, as $e'f'$, and placed on K to prevent any further supply or withdrawal of heat, and then suppose the piston to rise by the elastic force of the gas or vapor beneath, the temperature will fall by the conversion of sensible heat into mechanical effect, and artificial refrigeration will be unnecessary. Suppose that, when the piston reaches $e''f''$, the temperature is the same as that of B. The

* See Thompson's "Account of Carnot's Theory," in the Trans. of the Roy. Soc. of Edinburgh, vol. xvi, part 5, 1849.

cylinder may then be transferred to that body, and the piston pressed down, the temperature remaining at T°, until a third position, $e'''f'''$, is reached, which is such that, on again placing the cylinder on K, and completing the downward stroke, the temperature will again rise to S°. It thus appears that, of a certain definite amount of heat drawn from A, a certain less amount is given up to B, and the difference is converted into mechanical effect.*

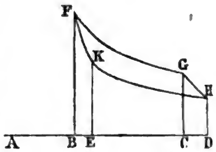
It is evident that, by reversing this whole process, that is, by first placing the cylinder on K, and allowing the piston to rise to $e'''f'''$, thereby depressing the temperature from S° to T°, then placing the cylinder on B, and allowing a further expansion to $e''f''$, the temperature being kept at T° by heat received from B, then transferring the cylinder to K again, and forcing down the piston to $e'f'$, so as to raise the temperature to S°, we may finally, by completing the downward stroke in contact with A, transfer to that body not only as much heat as was imparted by B, but also the additional amount expended in compression, above what was received during the expansion.

A gas or vapor engine constructed in conformity with this principle, is capable, therefore, if worked backward by force, of generating as much heat as is expended in its direct action, and of restoring the heat so generated to the original source. Such an engine is what Carnot defines to be a *perfect* thermo-dynamic engine. It is obvious from the nature of things, that no other description of engine, moved by heat, can convert a larger fraction of the heat drawn from the source into available power, than one of this kind: for, if there could be such an one, it would be capable of driving this one backward, and of thus constantly refunding to the source as much heat as it withdraws, while still preserving a balance of positive power—or, in other words, a balance of effect without a cause—which is impossible. We are thus furnished with a natural limit to the power obtainable by the expansion and compression of elastic fluids between given limits of temperature. Our first object then, must be to find a general expression for this effect, for the perfect engine. The illustrations which immediately follow are substantially derived from Thompson and Clausius, and would be superfluous, had the investigations of those writers been republished in this country.†

* According to Carnot's theory, which was identical with that which has hitherto been universally received, the amount of heat given up to B was *not* less than that derived from A, but exactly equal to it: hence the mechanical force exerted was presumed to be a natural concomitant of the transfer of heat from a hotter to a colder body, and not a conversion of the heat, or of any part of it, into mechanical effect.

† Clausius, on the Moving Force of Heat, &c., from Poggendorff's Annalen, vol. lxxix, republished in the Lond. and Ed. Phil. Mag., July and August, 1851. Thompson, in the paper above quoted—also Lond. Phil. Trans., part 1, 1852, and elsewhere.

2.



Suppose a column of atmospheric air, whose altitude is equal to A B, to be confined in a cylinder by a piston capable of moving without friction. Let the pressure it exerts upon the piston at the temperature S° be represented by the ordinate B F. Let it expand with unvarying temperature until the piston reaches the point C, and let the ordinate C G represent the pressure at that time. Let it now expand without receiving or imparting heat, from C to D, during which time the temperature falls to T°, and the pressure to D H. Let it now undergo compression, maintaining the invariable temperature T°, until the piston reaches E, a point such that the further compression, (without gain or loss of heat,) to the original volume, A B, shall restore the original temperature S°, and pressure, B F. It is evident that the area, F G H D B will represent the entire mechanical effect produced during the expansion, and the area, F K H D B will represent the force required to restore the air to its original state. Hence, the differential area, F G H K, will be the measure of the amount of heat converted into available force.*

Represent the original volume of the air, A B, by V', and the volume A C by V''; also A D by $V_,$ and A E by $V_{,,}$. Put τ' for the original temperature, S°, reckoned from the absolute zero (taken at 459° below 0° F.), and $\tau_,$ for the temperature T°, similarly reckoned. Then, according to Poisson's formula for temperatures as affected by expansion or compression,

$$\frac{\tau_,}{\tau'}=\left(\frac{V''}{V_,}\right)^{\gamma-1}, \text{ and also } \frac{\tau_,}{\tau'}=\left(\frac{V'}{V_{,,}}\right)^{\gamma-1}; \text{ or } \frac{V''}{V_,}=\frac{V'}{V_{,,}}$$

Now the area, G H D C, which measures the mechanical effect produced during the second expansion, may be found by integrating the expression $\int pdv$ between the limits V'' and $V_,$; substituting for p its value from Poisson's formula for pressure under these circumstances, viz.:

$$p=P''\left(\frac{V''}{v}\right)^{\gamma},$$

where P'' represents the pressure corresponding to V''. Hence the area in question is expressed by the formula,

$$\frac{P''V''}{\gamma-1}\left(1-\left(\frac{V''}{V_,}\right)^{\gamma-1}\right).$$

And, in like manner, P' representing the pressure corresponding to V', the area F K E B, which measures the force expended in the final compression, is expressed by

* Since the surrounding medium—the atmosphere, for instance—aids the compression as much as it opposes the expansion, no account need be taken of it.

$$\frac{P'V'}{\gamma-1}\left(1-\left(\frac{V'}{V_{\prime\prime}}\right)^{\gamma-1}\right).$$

But, according to Mariotte's law, $P'V'=P''V''$; and we have just seen that $\frac{V''}{V_{\prime}}=\frac{V'}{V_{\prime\prime}}$: whence the area G C D H is equal to the area F K E B; or, in other words, the second expansion is exactly balanced by the second compression:—a conclusion which we might, indeed, have independently drawn, since the same amount of heat which disappears in the expansion, reappears in the compression.

The area F G C B, according to the third general principle stated above, is the measure of the total amount of heat which the air has received from the source, converted into mechanical effect. To find its value we observe, first, that if p, v and t represent the simultaneous pressure, volume and temperature (reckoned from the absolute zero) of any gas, the expression $\frac{pv}{t}$ will be, for that gas, a constant quantity. And if we take p_0, v_0 and t_0 to express the values of these variables under ascertained circumstances, as for instance at Fahrenheit's zero, and under a given barometric pressure, then $\frac{p_0 v_0}{t_0}$ may be put $=$ R, and in any other condition of the gas we have $pv=\mathrm{R}t$, and $p=\frac{\mathrm{R}t}{v}$.

Now the differential of F G C B is pdv; whence, representing it by M (mechanical effect), we have,

$$\mathrm{M}=\int\frac{\mathrm{R}t}{v}\,dv=\int\frac{\mathrm{R}\tau'}{v}\,dv=\mathrm{R}\tau'\text{ h. l. }\frac{V''}{V'},$$

between the limits V′ and V″.

In like manner, area K H D E ($=$M′) will be

$$\mathrm{M}'=\mathrm{R}\tau_{\prime}\text{ h. l. }\frac{V_{\prime}}{V_{\prime\prime}}=\mathrm{R}\tau_{\prime}\text{ h. l. }\frac{V''}{V'}.$$

And the differential area, F G H K, which we will represent by W, will be

$$\mathrm{W}=\mathrm{M}-\mathrm{M}'=\mathrm{R}(\tau'-\tau_{\prime})\text{ h. l. }\frac{V''}{V'}.$$

If H, then, be the total amount of heat received by the gas, and of which the entire mechanical effect is represented by M, the fraction converted into available work will be found thus:

$$\mathrm{M}:\mathrm{W}::\mathrm{R}\tau'\text{ h. l. }\frac{V''}{V'}:\mathrm{R}(\tau'-\tau_{\prime})\text{ h. l. }\frac{V''}{V'}::\mathrm{H}:\mathrm{H}\frac{\tau'-\tau_{\prime}}{\tau'}.$$

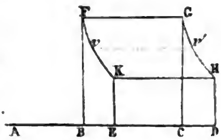
It is geometrically evident that no larger a fraction of the heat absorbed by a gas fluctuating between the temperatures τ' and $\tau_{\prime}$ can be made available, than that here represented; for the differ-

ential area cannot be enlarged unless the curve F G rise in some point above, or the curve K H descend in some point below, the logarithmic curve; which neither can do without transcending the limit τ' or $\tau_,$.

The practical difficulty of maintaining a body of air, while undergoing dilatation or compression, at an unvarying temperature, will render it always, probably, an impossibility to work an engine on this principle, and therefore to realize so large an advantage from the heat expended, as the extremes of temperature in furnace and refrigerator might lead us theoretically to anticipate. It is easy, however, to secure a constant *pressure*, and this presents the question of economy under a new form.

Suppose the air to expand from B to C, with rising temperature, and a constant pressure represented by F B = G C, then to expand, without receiving or imparting heat, to D, at the lower pressure H D, then to be compressed to E, with loss of heat and constant pressure E K = H D, and finally to be compressed to its original bulk, acquiring at the same time by the compression, and without receiving or imparting heat, the original temperature and pressure. The differential area, F G H K, bounded by the parallel straight lines F G, and H K, will represent the balance of positive mechanical effect. If we draw a line, as $v\,v'$, parallel to F G, it will represent the difference of volume of the air when at equal pressure in the two opposite processes of expansion and compression. Calling these volumes v and v', and the corresponding pressure p, we shall have (using the other symbols as before),

3.



$$p=\mathrm{P}'\left(\frac{\mathrm{V}'}{v}\right)^{\gamma}=\mathrm{P}''\left(\frac{\mathrm{V}''}{v'}\right)^{\gamma}$$

Or, as $\mathrm{P}'=\mathrm{P}''$, $\frac{\mathrm{V}'}{v}=\frac{\mathrm{V}''}{v'}$, and

$$\mathrm{V}'' : \mathrm{V}''-\mathrm{V}' :: v' : v'-v=\frac{v'(\mathrm{V}''-\mathrm{V}')}{\mathrm{V}''}.$$

But $v'=\mathrm{V}''\left(\frac{\mathrm{P}''}{p}\right)^{\frac{1}{\gamma}}$; whence $v'-v=(\mathrm{V}''-\mathrm{V}')\left(\frac{\mathrm{P}''}{p}\right)^{\frac{1}{\gamma}}$.

Now area F G H K $=\int_{\mathrm{P}_,}^{\mathrm{P}''}(v'-v)dp=\int_{\mathrm{P}_,}^{\mathrm{P}''}(\mathrm{V}''-\mathrm{V}')\left(\frac{\mathrm{P}''}{p}\right)^{\frac{1}{\gamma}}dp$

Or, observing that dp is negative,

$$\mathrm{W}=\frac{\gamma}{\gamma-1}(\mathrm{V}''-\mathrm{V}')\left(\mathrm{P}''-\mathrm{P}''^{\frac{1}{\gamma}}\mathrm{P}_,^{\frac{\gamma-1}{\gamma}}\right)=\frac{\gamma\mathrm{P}'\mathrm{V}'}{\gamma-1}\left(\frac{\mathrm{V}''}{\mathrm{V}'}-1\right)\left(1-\left(\frac{\mathrm{V}''}{\mathrm{V}_,}\right)^{\gamma-1}\right)$$

Where $\mathrm{P}_,$ represents the pressure at D or E, and is found in terms of P'' by the formula $\frac{\mathrm{P}_,}{\mathrm{P}''}=\left(\frac{\mathrm{V}''}{\mathrm{V}_,}\right)^{\gamma}$; after which P' is put for its equal P''.

We have now four temperatures. That which we have called τ' must be raised in the same ratio as the volume is increased during the expansion at constant pressure. Put τ'' for the temperature at volume V'', and also $\tau_{,}$ and $\tau_{,,}$ for those corresponding to $V_{,}$ and $V_{,,}$.

The mechanical equivalent of the total amount of heat in the air at volume V' and pressure P', may be found thus. In expanding from V' to any other volume, v, the pressure (p) becomes

$$p=P'\left(\frac{V'}{v}\right)^{\gamma}$$

And the work done, during an infinite expansion, will be

$$\int_{V'}^{\infty} pdv = \int_{V'}^{\infty} P'\left(\frac{V'}{v}\right) dv = \frac{P'V'}{\gamma-1}.$$

If, then, γ represent the ratio of the specific heat of air at constant pressure to that at constant volume, the mechanical equivalent of the heat absorbed, while the temperature is rising from τ' to τ'' and the pressure is constant, will be

$$\frac{\gamma P'V'}{\gamma-1}\left(\frac{\tau''-\tau'}{\tau'}\right)=M.$$

And, in the value of W above, $\frac{V''}{V'}=\frac{\tau''}{\tau'}$, and $\left(\frac{V''}{V_{,}}\right)^{\gamma-1}=\frac{\tau_{,}}{\tau''}$

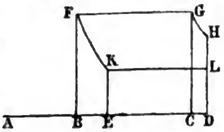
which, substituted, give us $W=\frac{\gamma P'V'}{\gamma-1}\left(\frac{\tau''-\tau'}{\tau'}\right)\left(1-\frac{\tau_{,}}{\tau''}\right)$

Whence $$\frac{W}{M}H=\frac{\tau''-\tau_{,}}{\tau''}H;$$

or the fraction of the heat absorbed which is converted into available work, is equal to the range of depression divided by the maximum temperature, as before.

In an air engine which discharges the air from the working cylinder at a pressure above that at which it is received into the supply cylinder, a less simple formula is required to express the economical ratio. In this case, if the valves are adequate to afford instant relief to the excess of pressure, the effect is the same as if the air, without being set free, were suddenly refrigerated to such an extent as to reduce the pressure to an equality with that of the supply before compression.

4.



In this case, F B C G may represent, as before, the work, done at the constant pressure P', and G C D H, that during the second expansion. D E K L will be the representative of the effect of the first compression; and F B E K that of the second.

Then $FBCG = P'(V''-V') = P'V'\left(\frac{V''}{V'}-1\right) = P'V'\left(\frac{\tau''}{\tau'}-1\right)$

And $GCDH = \int_{V_{,}}^{V''} P''\left(\frac{V''}{v}\right)^{\gamma} dv = \frac{P''V''}{\gamma-1}\left(1-\left(\frac{V''}{V_{,}}\right)^{\gamma-1}\right) = \frac{P'V'}{\gamma-1}\frac{\tau''}{\tau'}\left(1-\frac{\tau_{,}}{\tau''}\right)$

Also $KEDL = P_{,,}(V_{,}-V_{,,}) = P_{,,}V_{,,}\left(\frac{V_{,}}{V_{,,}}-1\right) = P'V'\left(\frac{V'}{V_{,,}}\right)^{\gamma-1}\left(\frac{V_{,}}{V_{,,}}-1\right)$

And $FBEK = \frac{P'V'}{\gamma-1}\left(1-\left(\frac{V'}{V_{,,}}\right)^{\gamma-1}\right) = \frac{P'V'}{\gamma-1}\left(1-\frac{\tau_{,,}}{\tau'}\right)$

In the third expression above, we have $\frac{V_{,}}{V_{,,}}$, the value of which we obtain by observing that,

$$V_{,} = V''\left(\frac{\tau''}{\tau_{,}}\right)^{\frac{1}{\gamma-1}}, \text{ and } V_{,,} = V'\left(\frac{\tau'}{\tau_{,,}}\right)^{\frac{1}{\gamma-1}} \therefore \frac{V_{,}}{V_{,,}} = \frac{V''}{V'}\left(\frac{\tau_{,,}\tau''}{\tau_{,}\tau'}\right)^{\frac{1}{\gamma-1}}$$

And $KEDL = P'V'\frac{\tau_{,,}}{\tau'}\left[\frac{\tau''}{\tau'}\left(\frac{\tau_{,,}\tau''}{\tau_{,}\tau'}\right)^{\frac{1}{\gamma-1}} - 1\right]$

Whence the area $FGHLK = P'V'\left[\left(\frac{\tau''}{\tau'}-1\right) - \frac{\tau_{,,}}{\tau'}\left(\frac{\tau''\left(\frac{\tau_{,,}\tau''}{\tau_{,}\tau'}\right)^{\frac{1}{\gamma-1}} - \tau'}{\tau'}\right)\right]$
$+ \frac{P'V'}{\gamma-1}\left[\frac{\tau''}{\tau'}\left(1-\frac{\tau_{,}}{\tau''}\right) - \left(1-\frac{\tau_{,,}}{\tau'}\right)\right] = W.$

The value of M is of the same form as before, since it depends only on V' and V''.

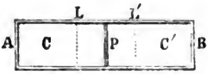
$$\text{Hence } \frac{W}{M}H = H\left[\frac{\gamma-1}{\gamma}\left(1-\frac{\tau_{,,}}{\tau'}\cdot\frac{\tau''\left(\frac{\tau_{,,}\tau''}{\tau_{,}\tau'}\right)^{\frac{1}{\gamma-1}} - \tau'}{\tau''-\tau'}\right) + \frac{1}{\gamma}\left(1-\frac{\tau_{,}-\tau_{,,}}{\tau''-\tau'}\right)\right]$$

When $\tau_{,,} : \tau' :: \tau_{,} : \tau''$, this expression becomes, as before $= H\frac{\tau''-\tau_{,}}{\tau''}$

When the maximum and minimum temperatures are given, the economy of working, in an engine of this description, depends on the intermediate temperatures $\tau_{,}$ and τ'. If, when the foregoing proportion holds, we vary $\tau_{,}$ and not τ', we lose, either way. But there may be a slight increase in the economical ratio, by increasing τ' a little above the value $\frac{\tau_{,,}\tau''}{\tau_{,}}$. This fact is illustrated in my article published in the March No. of this Journal. The effect of an increase of τ', is upon the whole to elevate the *source* of the heat, since all that is absorbed is received above this temperature. It is hardly necessary to say that these two quantities may be made to vary, by varying the proportions of the cylinders of the engine, or the position of the cut-off.

In the engine of Stirling, and all others resting on the same principle, we arrive at a similar form of expression for the economical ratio, though the expression for the work done assumes a simpler shape. In order to fix our ideas, we must first examine a theoretic case, which, in practice, it is somewhat difficult to realize.

5.



Let A B be an air-tight cylinder, in which a piston P, capable of moving without friction, separates completely two equal masses of air, C and C'. Suppose that, by the alternate and instantaneous changes of temperature of these masses, the piston traverses the space L L'. When it reaches one of these limits, let the temperature of the air before it be τ', and of that behind it $\tau_{,}$. Then, by an instantaneous change, let the former temperature rise to τ'', the maximum, and the latter fall to $\tau_{,,}$, which is the minimum. There are but two volumes here to be considered, and we may represent the minimum by V and the maximum by V'. Put also P = pressure at minimum volume, and P' = pressure at maximum volume, both being taken at the end of the stroke, and before the change of temperature. Then the maximum pressure will be $P\frac{\tau''}{\tau'}$; and in accordance with what we have already seen, the positive power exerted at each stroke will be

$$\frac{PV}{\gamma-1}\frac{\tau''}{\tau'}\left(1-\left(\frac{V}{V'}\right)^{\gamma-1}\right)$$

And the resistance $\frac{PV}{\gamma-1}\left(1-\left(\frac{V}{V'}\right)^{\gamma-1}\right)$

Whence $$W=\frac{PV}{\gamma-1}\left(\frac{\tau''}{\tau'}-1\right)\left(1-\left(\frac{V}{V'}\right)^{\gamma-1}\right)$$

But, in order to eliminate τ', so that the expression may contain only the maximum and minimum temperatures, which, being those of the source of heat and the refrigerator, may be supposed to be controllable, or known, we may take

$$\tau'=\tau_{,,}\left(\frac{V'}{V}\right)^{\gamma-1} \quad \text{whence}$$

$$W=\frac{PV}{\gamma-1}\left(\frac{\tau''}{\tau_{,,}}\left(\frac{V}{V'}\right)^{\gamma-1}-1\right)\left(1-\left(\frac{V}{V'}\right)^{\gamma-1}\right)$$

Also, as in the former case, the mechanical equivalent of the heat imparted is, (vol. being constant during the heating,)

$$\frac{PV}{\gamma-1}\left(\frac{\tau''}{\tau'}-1\right)=\frac{PV}{\gamma-1}\left(\frac{\tau''}{\tau_{,,}}\left(\frac{V}{V'}\right)^{\gamma-1}-1\right)=M.$$

Whence $$\frac{W}{M}H=H\left(1-\left(\frac{V}{V'}\right)^{\gamma-1}\right)=H\left(1-\frac{\tau_{,}}{\tau''}\right)=H\left(\frac{\tau''-\tau_{,}}{\tau''}\right)$$

If, in the expression for W, above, we make V, variable, we shall find that the maximum effect is obtained from a body of air, of which the minimum bulk and pressure are expressed by PV, when

$$V' = V\left(\frac{2\tau''}{\tau'' + \tau_{\prime\prime}}\right)^{\frac{1}{\gamma - 1}}.$$

An expansion to a volume approaching or exceeding two-fold is therefore usually necessary to obtain the greatest effect; and the ratio rises rapidly as the maximum temperature is increased while the minimum is constant; the index $\frac{1}{\gamma-1}$ being about 2·44 for air. For a maximum temperature of 480° F., and a minimum of 60°, V′ will be 1·8 V. For 750° maximum and the same minimum, V′ will be 2·25 V.

As the expression $\left(1 - \left(\frac{V}{V'}\right)^{\gamma-1}\right)$ is the measure of the heat made available, it is evident that the economy will increase with the expansion; but there occurs here, as in the other form, a negative pressure at the end of the stroke, after passing a certain limit. P′, which has been taken for the final pressure, will be expressed thus,

$$P' = P\frac{\tau''}{\tau_{\prime\prime}}\left(\frac{V}{V'}\right)^{2\gamma-1}$$

In the two cases above supposed, P′ = ·59P for the first, and ·52P for the second.

If we would impose a condition that there shall be no negative pressure at the end of the stroke, or that the final pressure shall bear any ratio, expressed by n, to the resistance, we shall have

$$P' = nP = P\frac{\tau''}{\tau_{\prime\prime}}\left(\frac{V}{V'}\right)^{2\gamma-1}, \text{ or } n = \frac{\tau''}{\tau_{\prime\prime}}\left(\frac{V}{V'}\right)^{2\gamma-1};$$

and if we make $n = 1$, we shall have

$\frac{V'}{V} = \left(\frac{\tau''}{\tau_{\prime\prime}}\right)^{\frac{1}{2\gamma-1}}$ which limits the expansion to about once and a half the minimum volume, in the cases foregoing; V′ being equal to 1·4 V and to 1·6 V in those cases respectively.

By substituting 2V and 1·5V successively, for V′, in the expression $\left(1 - \left(\frac{V}{V'}\right)^{\gamma-1}\right)H$, we find that the fraction of heat converted into available power is ·25, in the first instance, and ·15 in the second. Engines upon this principle will not therefore compare, in point of economy, with those which use compression cylinders. This will be manifest by comparing these results with those given in the March number of this Journal. It is true that, by the use of the regenerator, there may be theoretically a large saving. All the heat absorbed, which is not expended in work-

ing, may, in theory, be taken up again by a regenerator; but it does not follow that all may be again restored to the air. In order to save all the heat, the regenerator should be capable of reducing the temperature, at the close of the stroke, to $\tau_{\prime\prime}$; but all which it absorbs between τ' and $\tau_{\prime\prime}$ will be lost. Moreover, a regenerator cannot maintain a temperature lower than τ' on its coldest side, so that it will be incapable of alone depressing the temperature sufficiently. All the heat taken in cooling between the limits just named, is invariably lost.

There is, of course, in this form of engine, as in that which employs compression cylinders, a point beyond which a regenerator would be of no avail. This contrivance is confined in its efficiency, to the limits of temperature, $\tau_{\prime}$ and τ'. If we put these temperatures equal to each other, we shall have

$$\tau_{\prime} = \tau''\left(\frac{V}{V'}\right)^{\gamma-1} = \tau' = \tau_{\prime\prime}\left(\frac{V'}{V}\right)^{\gamma-1} \text{ or } \left(\frac{\tau''}{\tau_{\prime\prime}}\right)^{\frac{1}{2(\gamma-1)}} = \frac{V'}{V}.$$

Thus, in case that τ'' is double of $\tau_{\prime\prime}$ which will be approximately the case in practice, there will be no advantage derived from a regenerator, when the expansion exceeds, $2\frac{1}{3}V$; but as this is beyond the limit of maximum power, the limitation is of little practical importance.

The difficulty of employing a regenerator with thoroughness at all, is a more serious disadvantage. Stirling was able to pass but a portion of the air through this contrivance: and, as a general rule, where the working piston is in direct contact with the air during the heating process, a certain portion of the mass must escape heating or refrigeration, or must be very imperfectly affected. Moveable regenerators, to take the place of Stirling's plungers, have been suggested by several persons; but besides that their weight would be an objection, they would be less easily kept down in temperature on the cold side, while it does not appear that they have any decided advantage over fixed ones.

There is also great difficulty in applying furnace heat to the air in these engines. This was one of Stirling's most serious troubles; and mainly in consequence of this fact, it is probable that no new attempt will be made to construct an engine strictly on the principle now under consideration.

By a modification of the principle, however, and by employing two supply (or heating) cylinders, in aid of each working cylinder, in one of which the air is in preparation, while in the other it is expanding into the working cylinder beneath the piston, an approach may be made to a realization of the degree of power which theory indicates.

Those who have turned their attention to the planning of engines without compression cylinders, have done so chiefly for the sake of getting rid of what has appeared to them a great evil, in

the resistance of the supply cylinders. But to secure the same power from the same mass of air between the same limits of temperature, on this principle, we must employ a degree of expansion which will produce precisely the same negative pressure at the close of the stroke, which the compression cylinders create. If we work without negative pressure, we do only what can be done in the other form of engine by lengthening the cut-off. And if, in this one, we use air previously condensed, as Stirling did, we do only what Ericsson is doing now. Moreover, if we allow no negative pressure, the range of temperature through which we work, must be very limited.

It is true that the pressure, per square inch of piston surface, will, other things being equal, be in favor of the engine without compression cylinder. But it is a fallacious conclusion to infer that therefore the effective power of the engine will be increased. If we put a to represent the area of the piston, then the length of the stroke will be $\frac{V'-V}{a}$; whereas in the other form the stroke is $\frac{V'}{a}$, and this larger motion is a full compensation, other things being equal, for the less mean pressure. On these accounts, and from the much greater facility of heating and cooling the air on the Ericsson plan, the preference seems to be due to that form of the engine.

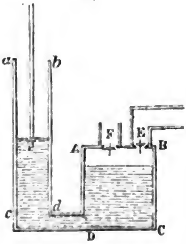
It is to be observed that, in all these comparisons, *the mass of air heated* is supposed to be the same. To compensate for the disadvantages of engines on the Stirling principle, it has been proposed by some to greatly increase the volume of air heated, to make the expansion a less fraction of the volume, and thus to carry a high pressure to the end of the stroke. This is to contradict the principle apparent in all the formulæ above obtained, that true economy requires a large range of fall in temperature in working: for though the regenerator is presumed to compensate for the absence of this, it cannot do so unless, as in Stirling's engine, it acts upon the air in the cylinder itself, or at least without allowing it to expand beyond the capacity of the cylinder—a matter of great difficulty—and at best it furnishes but an inadequate compensation. Moreover, as much advantage is gained by increasing the mass of air heated, in one form of engine, as in another. And since one of the main difficulties is to heat the air at all, it is an unwise expedient to attempt to provide against other disadvantages, by adding to this very serious, and hitherto, on the large scale at least, apparently insurmountable one.

It is perhaps worth considering, whether a more serviceable engine than has yet been invented, might not be made by combining, to a certain extent, the two principles. If two supply cylinders alternately furnish the charge for one working cylinder,

and if each supply cylinder somewhat condenses its charge and holds it exposed to heat, while the other is acting, and finally if the heated charge is not now, as in Ericsson's plan, forced into the working cylinder, but allowed to expand into it, we shall have probably a more thorough heating (or *time* for it at least) than has yet been secured, a higher mean pressure (compensated however by reduced length of stroke) and what is of principal importance, a larger working range of depression of temperature without negative pressure, than either principle alone will furnish. The number of parts would be increased by such a construction, and the machine would become less suited for locomotion than at present; but, as the supply pistons would act alternately, there would be no larger amount of friction to overcome than in Ericsson's.

One of the most serious obstacles in the way of the success of the air-engine, is the difficulty of obviating the effects of the great heat in the working cylinder. This is injurious or destructive to every thing organic, and renders close packing almost impossible. Could a liquid be found, capable of enduring a high heat, this might be made the medium of transmitting pressure, and the working cylinder might be kept absolutely cold. Let *a b c d*, for instance, be a cylinder, in which moves the piston, P. Let this cylinder communicate with the larger one A B C D, closed at top, but communicating with an air heater, by the valve E. A B C D being filled with a liquid, and also *a b c d*, up to the working piston, air may be admitted to the first, which will transmit its pressure through the liquid to the piston. A valve, F, may then discharge the air. By keeping the bottoms of the vessels, and the connecting channel, cold, the working cylinder will be likewise kept cool. No known liquid, however, would answer this purpose, unless it should be oil; and that would not answer at the high temperatures which have been proposed.

6.



Perhaps the idea is not entirely absurd of filling the chamber A B C D with the fusible alloy of lead, tin and bismuth, which liquefies at about 212° F. The high specific gravity would render great change of level undesirable, and hence A B C D might bear a large ratio in cross section to *a b c d;* while the latter cylinder might still contain oil, and the alloy might be chiefly confined to A B C D and the communicating passage.* By this means the temperature of the working cylinder might be kept lower than that of a high pressure steam engine. The tendency of the alloy to oxydize would be an evil which would require to

* Below the range of the piston, however, *a b c d* should be equal to A B C D.

be provided against in some manner—perhaps by employing air previously condensed, of which the oxygen had been converted into carbonic acid by passing thoroughly through the fire.

Since the great advantages which the air-engine holds out seem to be so nearly within our reach, and since we seem at present to be debarred from them only by obstacles such as the ingenuity of man has heretofore repeatedly surmounted, it is not only greatly to be hoped, but even to be reasonably expected, that we may soon see the invention perfected, and the important object which has hitherto in a great measure frustrated effort, successfully achieved.

University of Alabama, April 25, 1854.

ART. XXII.—*On the first Hurricane of September* 1853, *in the Atlantic; with a Chart; and Notices of other Storms:* by W. C. REDFIELD.

(Concluded from p. 18.)

West African Hurricanes, and Gales of the Eastern Atlantic between the Tropics.

As the great hurricane whose path we have already indicated, appears to have been of African origin, it may be well to show that the occurrence of storms in this region is not uncommon.

1. A violent hurricane swept over St. Nicholas, one of the Cape Verde Islands, lat. 16° 33′ N., lon. 24° 20′ W., on the second day of September, 1850. Its duration exceeded twenty-four hours; although the chief damage was done in three or four hours, during the morning of that day. All the crops, and nearly six hundred houses, were completely destroyed.* The marine accounts from the vicinity, date this gale on the third; doubtless in nautical time.

The ship *Sir Robert Peel*, for Bombay, after a run of about 120 miles from Bona Vista, encountered this hurricane Sept. 3d, and was completely dismasted.

The *New Margaret* was dismasted in the hurricane on the same day, in lat. 18° N., lon. 25° W.

Ship *Sir Edward Parry*, was in the hurricane Sept. 4th, off the Cape Verde Islands, St. Antonio bearing E. N. E., about 80 miles, [lat. 16° 30′ N., lon. 26° 40′ W]. It came on from eastward, increasing in violence till it blew the masts out of the vessel, while under bare poles.

H. M. S. *Portland*, encountered the gale in this vicinity.

The *Eliza Johnson* was spoken Sept. 20, in lat. 6° N., lon. 22° W., having lost mizenmast and topmasts in the gale, about two weeks before.

* London Times, Feb. 1st, 1851: p. 3.

Most of these vessels put into Rio Janeiro, where these reports were obtained by Capt. Theodore Lewis, from whom I received them in New York.

I can find no reason for doubting the continental origin of this hurricane. Its progression was evidently slow: and its subsequent course is placed under some doubt by the following report from the *Russell*.

The *Russell*, from Salem for Rio Grande, was spoken 24th Sept., lat. 4° N., lon. 20° W., by the *Richard Thornton*, arrived in the Thames from Batavia, and reported having experienced a hurricane on the 6th Sept., in lat. 28° N., lon. 32° W., in which she lost fore-topmast and main top-gallant-masts, boats, &c., also topsails, courses, jib., &c. blown away.

The position and date here given, led me first to lay down the track of this gale as having recurved on a route which passes between Teneriffe and the Azores. But the meteorological observations made by the British consuls at the Azores and Madeira, for the English Government, with other observations collected by Mr. Hunt, Consul General at St. Michaels, which were communicated by the government to Col. Reid, and by him kindly sent to me, do not render this course probable: unless the gale passed near to the Canary Islands, from whence no definite report could be obtained. The route of the gale, therefore, was probably westward; corresponding to Track XXIV. If we suppose the correct latitude to have been 18°, instead of 28°, it will place the *Russell* in a far more probable position, and one which sufficiently coincides with the foregoing reports. The nautical date, however, will then appear about one day in advance; unless the progression of the storm was at the low rate of about five miles an hour The log-book of the *Russell* might solve these doubts. On the westerly course thus indicated, the gale may have passed Bermuda about the 15th of Sept., where there were full indications of the proximity of a slow moving gale. This would show an average progression of between eight and nine miles an hour. Track XXIII.

2. Mr. Piddington has adduced the case of a cyclone passing out from the coast of Africa, to the northward of the Cape de Verdes, on a W. by N., or W. N. W. course, giving to the ship *Devonshire* as she first stood to the S. S. W., and then hove to, about 120 miles westward of St. Antonio, a severe gale from N. E. to South.*

I add here notices of three other gales, in this part of the Atlantic.

3. The *Superior*, from Harbor Grace for Barbadoes, reports as follows: Oct. 14th, 1850, in lat 24° 59′, lon. 47° 10′, experienced

* Piddington's Horn Book for the Law of Storms; 2nd edition, p. 31.

a terrific hurricane, which capsized the vessel at 5 A. M.; cut away both masts, when she righted, and all hands got safely on board again; water eighteen inches above the cabin floor; succeeded in clearing the wreck, and getting under jurymasts.

4. Ship *Damascus*, from Philadelphia for San Francisco, on the 18th of October, 1850, in lat. 25° 58′ N., lon. 41° 19′ W., encountered a severe hurricane, split foresail, main spenser and jib; also blew away main-topsail: after the stormsails were blown away the ship became unmanageable. On the night of the 18th the hurricane moderated.—See the positions on the Chart; marked XXV and XXVI.

The next case, in Sept. 1853, I find in Maury's Sailing Directions, 6th edition; received from the author.

5. The ship *John Wade*, for San Francisco, Sept. 27, lat. 17° 44′ N., lon. 35° 10′ W.; barometer 29·90; wind E., fresh breezes and clear. Sept. 28, lat. 15°, lon. 34° 50′, barometer 29·40; winds E. and E. S. E. First part, fresh breezes; middle part, strong gale. At 8 A. M. hove to under close reefed maintopsail. At 8, barometer 29·60; at 10, 29·7; at 12 M., 29·3. Sept. 29, lat. 14° 32′, lon. 34° 31′, barometer 29·60; winds W., S. S. W. Heavy gale, with violent squalls of wind and rain; middle part, sharp lightning; latter part, moderate; made sail. Capt. Little adds, "I think I was near the track of a hurricane."

The position of this gale appears to coincide nearly with the route of our hurricane of Track XXIV, which was four weeks earlier. The reported directions of wind indicate that Capt. Little crossed the center-path while within the limits of the gale. See XXXI of Chart.

6. To this series may be added a gale or hurricane encountered by Capt. Lavender, in the ship *Roman*, from Canton, Aug. 21, 1832, in lat. 12° 51′ N., lon. 39° 26′ W.: in which, according to Capt. L.'s memorandum,—split the fore-topsail, and scudded five hours under bare poles: ending with cross seas from *N. E.* and *southward*. The center-path of this gale was probably a little south of track XXIV on the Chart.

Other notices of gales in this region have met my eye, in former years; and one shipmaster stated to me that he had encountered, off the Cape Verde Islands, a severe gale of three days duration. This seems to indicate a remarkably slow rate of progression in that gale.

7. Capt. Fitzroy informs us, that on leaving Rio Janeiro for the Cape Verde Islands, early in August 1830, he first steered eastward and crossed the equator far east, which carried him into that tract of ocean between the trades which "in August and September is subject to westerly winds,—sometimes extremely

strong,—and encountered *a very heavy gale;* although so near the equator."* This is likely to have been one of the gales of August which afterwards visited the western and northern portions of the Atlantic, with great severity. Indeed, I strongly suspect this to have been the gale which passed St. Thomas on the 12th, and New York on the 17th of the month; as shown in my first paper on the character and progress of these gales.†

Capt. Fitzroy states, also, that at Port Praya, [lat. 14° 53′ N., lon. 23° 30′ W.,] no vessel should deem the bay secure during July, August, September and October,‡ because southerly gales sometimes blow with so much strength, and the rollers sent in by them are so dangerous to ships; and having experienced the force of these gales in the vicinity of the Cape Verde Islands, he confidently warns those who are inclined to be incredulous about a gale of wind being found in 15° of north latitude; beyond the [supposed] limits of the hurricane regions.§

8. If from this inter-tropical field we extend our inquiries northward to the Canary Islands, in lat. 28°, near the African coast, we may learn of other active cyclones that have crossed these Islands, in pursuing their orbital course to the shores of northern Africa and southwestern Europe. The route of one of these storms which passed near the Island of Madeira in October 1842, as shown by Col. Reid, is seen on the Chart.‖

9. I find record of another great storm, which passed over the Island of Teneriffe, on the 6th of November, 1826.

Track XVIII, seen further westward on the Chart, is the inferred route of a severe hurricane, in 1828, which was reported to me by Capt. Corning: long known as an intelligent merchant and navigator.

These several cases, together with Col. Reid's Bermuda hurricane of Sept. 1839,¶ the track of which is seen on the Chart, and that of Capt. Maclean of Sept. 1853, of which reports are annexed, are submitted as indicating the general course of progression of inter-tropical cyclones, in the eastern Atlantic; and their occasional identity, as well as systematic conformity, with those which visit the more northern portions of this oceanic basin.

* Voyage of the Adventure and Beagle, (Surveying vessels), vol. i, pp. 1 and 3.

† This Journal, First Series, vol. xx, p. 34–38.

‡ These are the months which constitute the "hurricane season" of the Windward Islands of the West Indies, where, as we have formerly shown, the hurricanes arrive from a more eastern portion of the Atlantic. We have now, more than presumptive evidence of their African origin.

§ Voyage of Adventure and Beagle, vol. i, p. 53.

‖ See Col. Reid's Progress of the Development of the law of Storms, p. 275—279: Where is found also an account of a gale in the S. E. part of the Mediterranean.

¶ For a full account of this hurricane, see Col. Reid's Attempt to Develope the law of Storms: 2nd Edition, p. 444–448.

Capt. Maclean's Hurricane, of September 27th, 1853.—In passing over the several violent hurricanes of the past Autumn, of which I have more copious notices, I select only the present case, because its recurvation was eastward of Bermuda. A good account of this storm is given in the London Shipping Gazette of November 8th, by Capt. Maclean, who had studied the cyclones, and was thus well prepared to meet their emergencies.

His ship, the *Gilbert Munro*, left the Island of St. Lucia on the 8th of September, and lost the trade wind on the 13th, in lat. 24° 33′ N. Light winds followed, with a high barometer, till on the 26th the weather became dark and gloomy, and the wind veered to E. S. E. and S. E. At noon, in lat. 33° 10′, lon. 59° 07′, the aneroid barometer had fallen $\frac{2}{10}$ths, and the mercurial barometer began to sink also. In the night following, the wind, at S. E., increased to a fresh gale, with squalls: [Being under the right limb of the gale, then near its point of recurvation.] At 4 a. m. of 27th the wind abated; but as the morning advanced it again freshened, from S. S. E., and the bar. had fallen $\frac{4}{10}$ths; at 10 a. m. hard gale, and bar. still falling; made the necessary preparations, being certain, from the direction of the wind, that the center was to the S. W., if a rotary storm, and would soon overtake us, in its progress northeastward, and that we should then have the gale from an opposite point.

At noon of 27th heavy gale at S. S. E., and heavy sea; lat. 35° 19′, lon. 56° 36′; rain fell in torrents till 1·30 p. m., when it ceased; barometer falling rapidly. Soon after there was a lull, and in ten minutes a full calm. Being now certain of an opposite wind, had but just time to prepare for it, when it burst upon us with increased fury from N. W., veering afterwards to N. N. W. and N. N. E. At 2 p. m. it blew a perfect hurricane, with dangerous cross sea. At 2·30 p. m. the ship was blown on her beam-ends; but with great exertions was payed off before the wind, and run admirably. It continued to blow with great violence till near midnight; when the wind backed to N. N. W., the barometer rising; and at daylight of 28th had abated to a common gale. At 8 a. m. more moderate.

Capt. M. commends a knowledge of the law of storms to every shipmaster and nautical man.

The brig *Samuel and Edward*, reports having experienced the hurricane Sept. 28th, lat. 34° 40′, lon. 56° 20′, from S. to N.; lost sails; &c., and lay ten hours under bare poles.

The Schooner *Werada* took the gale in lat. 35°, lon. 59°; and while scudding under close reefed sails, was taken aback by the hurricane from N. W.

At Bermuda, lat. 32° 15′, lon. 64° 40′, heavy rains at this period, with a very strong N. E. gale [force marked 10], from about noon of 26th to evening of 27th, veering to N.; thus showing

the left side of the cyclone. Barometer at 4·30 P. M. of 26th, 29·72. At 7·30 A. M. of 27th, 29·84.* See Track xxx of the Chart.

The foregoing notices of storms of inter-tropical origin in the eastern Atlantic, may serve to show their analogies and relations to those previously traced in the western Atlantic, and in the North American states. Let us now pass westward in the same parallels, to the nearer portions of the Pacific Ocean.

Gales of the Eastern Pacific, near the Mexican Coast.

Our direct knowledge of the paths of these gales is necessarily limited; but the interests of an increasing commerce, as well as of meteorological science, claim the notices which follow.

1. The *Joseph Butler*, on or about the 24th of June, 1850, encountered a severe gale of wind, near lat. 16° N., lon. 107° W., [260 miles from the shore of Mexico,] which carried away her mainmast. I have no further accounts of this gale.

2. The barque *Como*, on the 5th of August, 1850, in lat. 14° 20′ N., lon. 117° W., encountered a severe gale, commencing at N. and veering to W. and south. Lost sails and bulwarks, and sustained much other damage. These winds denote a course of progression corresponding to that of the hurricanes in the West Indies, and that the vessel was in the left side of the storm-path.

3. Niagara's Hurricane.—The *Niagara* was dismasted in a hurricane Sept. 9th, 1850, about ninety miles south of Acapulco: [lat. 15° 16′ N., lon. 99° 50′ W.]

The *Diana*, Sept. 11th, lat. 22° N., lon. 116° W., had a severe hurricane from N. E., veering to S. W.; blew five hours; vessel hove on beam-ends.

The Diana's position was in the left side of the storm-path, but near to the axis line; the progression of the storm being still northwesterly. Its course of progression from the *Niagara* was 34° north of west; or W. N. W., nearly. Its rate of progress was nearly twenty-three miles an hour; allowing no error for the nautical dates. Part of the track falls on our Chart. See Track xxviii.

4. The *Laura*, Sept. 26, 1850, lat. 26° N., lon. 123° W., in a severe gale was thrown on her beam-ends; lost cargo, &c. I have no further account of this gale.

5. The *Kingston*, from San Francisco for Panama, experienced a severe gale on the Mexican coast, and was thrown on beam-ends, Oct. 1, 1850, in lat. 14° N.; and reports that the gale swept the whole coast with great violence; as may be seen in the succeeding statements.

The *Belgrade*, from San Francisco for Realejo; Oct. 1, fine breeze from W. N. W., and *heavy swell from S. E.* At 10 P. M.

* From Signal Station Reports in Bermuda Gazette.

wind hauled suddenly to S. E., with increased force and squally appearances; at midnight under single reefed topsails; 1 A. M. still increasing, with vivid lightning and heavy rain; 4 A. M. split fore-topsail; 8 A. M. lost foresail; gale increasing to a hurricane; thrown on beam-ends, with loss of main and mizen-topmasts, with head of mainmast, when the ship righted a little. At 1 P. M. Oct. 2nd, hurricane still increasing, ship on her beam-ends; lost fore-topmast, with much other damage; at midnight, blowing as hard as ever; at 4 A. M. Oct. 3d, more moderate, heavy rain; Oct. 4th, lat. 18° 11′ N., lon. 104° 5′ W., made for Acapulco. It may be seen that this vessel was on the right of the axis path of the storm.

The *Galindo*, on the same route, experienced a severe hurricane on the 1st and 2nd of October; was thrown on beam-ends and dismasted; and arrived at Acapulco at the same time with the *Belgrade.*

The *Lovina*, off Cape San Lucas, the southern point of California, Oct. 5th, was thrown on beam-ends in a violent hurricane, and lay twenty-one hours.

The *Fanny*, from Mazatlan, in the gulf of California, for San Francisco, was damaged in the gale, on the 5th and 6th of October, and put back to Mazatlan.

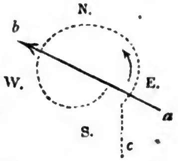
The progress of this hurricane, during four days, appears to have been N. W. by W., nearly; at a rate not exceeding eight or ten miles an hour. Part of this track falls on our Chart: Track XXIX.

6. AMAZON'S HURRICANE.—The brig *Amazon*, from New York for San Francisco, encountered a severe hurricane Oct. 3d, 1850, in lat. 13° 30′ N., lon. 116° 50′ W.; which commenced at S. W. veering successively to S. E.; E.; N.; W.; ending at S. W.; in which lost main-topsail and foresail. Capt. Watt states that the gale was equally severe as those in the West Indies. This off-shore hurricane was cotemporaneous with that last noticed. The following is drawn from the account which was published by a passenger of the Amazon.

Oct. 4th, lat. 13° 40′ N., lon. 116° 30′ W.: last night the brig encountered a hurricane, preceded by squalls from S, W., with heavy rain. The squalls increased in number and intensity, until 5 P. M., when the hurricane commenced; brig under close-reefed fore-topsail and mainsail. Capt. Watts put his vessel before the blast, or "scudded" her. The tempest raged during the night, with momentarily increased fury. It veered from S. W. to due south, thence to S. E., and thence to N. E. and north, and from thence to S. W., thus making the circuit of the compass! According to our reckoning, it veered thirty-four points in the space of six hours; during which time the brig was kept before it, in which lay our only chance of escape. At 4 A. M. the

foresail was blown from the yard, and the vessel was then brought to the wind, but could not withstand the tornado, and was blown directly down on her side, or beam-ends. Apprehending she would founder, the order was given to put her again before the wind, but the attempt was unsuccessful. As a last resource, the main-topsail was let go, when she paid off, and dashed away like lightning before the tempest. She was kept scudding till the hurricane ceased and was then laid to in a heavy gale from S. W., which followed the hurricane.

From the above we may infer that the course of the vessel while scudding, was not unlike that shown in the annexed figure.



a b Course of the storm's progression.
c Course of the *Amazon* in the gale.

The short time in which the brig ran entirely round the axis of the gale, after entering its violent portion, shows that its diameter was small; and that its progression was remarkably slow. This slowness is also shown by the manner in which the brig, steering N. for San Francisco, was able to *overtake* the cyclone, and run into it, upon its southeastern side, where its wind was southwesterly. Hence, too, after clearing the vortex of the cyclone, and heaving to, the duration of the exterior portion of the gale was so much prolonged, notwithstanding the drift of the vessel was in a direction opposite to the progression of the storm. It is probable that this progression did not exceed four miles an hour; and it may have been less.

This is a slower rate of advance than I have yet found on the Atlantic; but it accords well with other cases which have occurred within the tropics, in the Indian Ocean. It appears, also, as having some relation to the slow rate of advance already noted in the cotemporaneous in-shore hurricane of the *Kingston*. Hence, we may infer, that the great current of rotation in which the cyclones are imbedded was at this period and in this region, at least, comparatively sluggish and inactive. We have noticed a similar condition in the Eastern Atlantic, in the previous month; in the case of the Cape Verde hurricane, of Track XXIII.

7. Capt. Budd's Gale, of Oct. 1851.—Capt. Budd's steamer from San Francisco, for Panama, was on the 21st of October in lat. 22° 07′, off Cape San Lucas. At daylight of 22d the wind was very high, hauling to S. E., preceded by *a heavy swell from the same quarter*. The gale blew heavy from S. E, and then commenced hauling to N. E., and blew still more heavy: barometer 29·75. He had now crossed the entrance of the Gulf of California, to within sixty miles of Cape Corientes. At 4 P. M. gale abating, and hauling to the westward, going round by the north.

The winds in this case appear to indicate that Capt. Budd fell under the right hand or northern side of the gale, as it first ap-

proached; and that the gale recurved northward, upon the contiguous portion of Mexico, before the axis of the storm had reached the position of the ship. See Chart.

8. PANAMA'S GALE, OF JULY 1852.—The *Panama*, experienced a hurricane July 16, 1852, in lat. 15° N., lon. 115° W.; which lasted ten hours: carried away top-gallant-masts, yards, sails, &c.

Extract from logbook of ship *Empire*, bound for San Francisco: July 19th, 1852, commences with heavy gales and bad sea, from the north; under double-reefed topsails and courses: [ship in front part of the gale, to the left of its axis path]. At 8 P. M. heavy gale from N. N. W.; at 10 P. M., very heavy gale; hove the ship to under triple-reefed main-topsail; midnight, gale increased to a hurricane; the mainmast went by the board, together with the mizenmast, fore-top-gallant-mast, &c., with every thing attached; blowing a complete typhoon. At 5 A. M., succeeded in clearing the wreck; at 7 A. M. gale had in some measure abated, and at 8 A. M. got the ship before the wind, then blowing from S. S. W.; at noon of 20th, only a brisk gale from S. S. E. Lat. by account, 17° 4′ N., lon. 117° 35′ W.

This could have been none other than the Panama's gale, moving on a course between 30° and 40° north of west; and, if there be no error in the Panama's date, at the rate only of about three miles and a half per hour!

This slowness of progression, in the three hurricanes of the *Panama*, *Amazon*, and *Kingston*, is of great interest for navigators in the Pacific. For it shows how perfectly the exposure and safety of their vessels, during such hurricanes, are placed in their own control; at least, in cases where sea room on all sides is afforded them. Thus, if the master of the *Amazon* had comprehended the character of his hurricane, or its law of rotation and progression, he might have run more eastward until the state of the barometer and winds would have allowed him to come up to his desired course. This would have enabled him to make a safe, rapid, and successful run, towards his port of destination, while he kept in the outskirts of the gale.

The *Empire*, when headed off by the north wind in the front of the gale, could not pursue her course for San Francisco, nor safely heave to, on either tack. But she had opportunity to run southward in the beginning of the gale, keeping the wind on the starboard quarter, until the state of the barometer and the diminished strength and westerly changes of the wind should enable her to turn eastward, around the rear of the hurricane, and thus regain her course with a fair wind.

9. A violent hurricane occurred at Cape Corientes and Ipala on the night of October 11th 1853; in which the *Eclipse*, a valuable ship, was totally lost, about five miles east of Ipala: [in lat.

20° 10′ N., lon. 105° 25′ W.] It first blew off the land, from the northward, and shifting suddenly to the westward, blew a perfect hurricane, right on shore. This may indicate its recurvation near the southern entrance of the Gulf of California at Cape Corientes. It has been shown that some hurricanes of the gulf of Mexico, commence their recurvated course to the northward and eastward in a still lower latitude. For such a case, see this Journal, vol. i, New Series, p. 153–162.

The inter-tropical gales of the North Pacific which are comprised in these few notices, are seen to have occurred in the several months from June to October, both inclusive; and I have now before me an account of another violent gale, far to the westward, in the month of May. The prevalence of storms on that coast in the other months, from October to April, has been noticed by Humboldt and other writers; and is now but too well known by the experience of navigators.

We thus establish the prevalence of violent cyclones upon the southwestern coast of North America at all seasons of the year: and find that these are sometimes of great violence. That many of these cyclones pass over the Mexican territories, some to the gulf of Mexico, under the local name of *northers*, and others to the territory of the United States, I can find no reason to doubt.

The very prominent characteristic of southeast winds, in the storms which commonly visit the Pacific coast, affords evidence of their progress along the coast in the lower latitudes, and of their direct entrance upon those shores in higher latitudes, subsequent to their northwardly recurvation. These characteristics early attracted my attention, in the gales which are noticed in the voyages of Cook, Vancouver, and others, and in the Journals of whalers, which came under my inspection.

We might infer, therefore, without reference to other and direct evidence, that the same general system of cyclonic movement prevails on the continent of North America that is found on the Atlantic. Indeed, a glance at our storm Chart might afford conviction of this fact.*

A competent knowledge of the cyclones and of the law which governs their development, has become essential to our navigators. Both merchants and insurers are beginning to discover that even the good qualities of a vessel have commonly less influence upon the safety of her voyage, than has the intelligence and skill of the commander. Hence, there are now insurers who freely select those risks which are in charge of the most compe-

* In almost every region of the Pacific, violent cyclones are known to occur: and even within five or six degrees of the equator, the ravages of a hurricane at certain islands have occasioned the destruction of a large portion of the native population. The results of the recent inquiries have now shown, by direct observations, the prevalence of the cyclonic system of storms entirely around the globe, in both hemispheres; excepting some interior or inaccessible portions of the old continent.

tent masters; leaving other risks of whatever class, to underwriters who are willing to rely on the classification of the vessels.

American Storms of December 1836.

From the 30th day of November to 21st December, 1836, six great cyclones passed successively over the United States; having passed New York on Nov. 30th,—Dec. 5th,—10th,—14th,—17th, and 21st, respectively: under which, my barometer fell ·62,—·35,—·44,—·86,—·90, and 1·05 in., in the several cases.* The surrounding waves of exterior pressure raised by their rotation, and separating each cyclone from the other, were indicated by my barometer as follows, viz.: Nov. 28th, 30·27; Dec. 4th, 30·29;—8th, 30·35;—12th, 30·28;—16th, 30·45;—19th, 30·80; and Dec. 22nd, 30·72 inches. Each cyclone exhibited here the winds of its two right quadrants, gradually veering, from a southern quarter to the western board, as it went onward; thus showing the cyclonic centers to have passed far westward of New York, and over the Canadas, in their several routes to the northern regions of the Atlantic.

In the last of these storms, which has been examined by Prof. Loomis,† the wind at New Orleans, on the 20th, blew hard from a southern quarter, and also on our Atlantic coast, during the latter part of 20th and early part of 21st; veering westward. At Rochester, N. Y., it blew from southeast on the afternoon of 20th, with great power, and furiously at Buffalo, also veering round by the south to the west, during the night; thus showing that the axis of this gale passed northwardly at a distance much to the west of these places. This fact is confirmed, also, by the reports of winds as made to the Regents at Albany, and by those obtained from the military posts and other sources; very many of which are given by Prof. Loomis. The same fact is shown by barometric observations as published by him. For although the central nucleus of the storm, or area of greatest barometric depression, passed the western observers during the night, when the greatest and most rapid fall and rise of the barometer was not noted, yet, the depression as recorded proves to be greatest as we go towards the true center-path of the storm, as the same is approximately indicated on the Chart: marked XXVII. This is seen in the observations made at Lexington, (K.) Springfield, (O.) Marietta, Twinsburg, Rochester, Syracuse, Albany, Montreal, Hanover, and Quebec; which, even as given, show a mean fall of 1·075 in.: while those of twelve places on or near the Atlantic border, from Savannah to Newfoundland, show a mean fall of

* This series may serve to illustrate the continued succession of cyclones in the United States.

† Transactions of the American Philosophical Society, vol. vii, New Series, p. 125–164.

but ·91 in. If the true course of the storm had been from west to east, the fall in the barometer would have been much the greatest on the Atlantic border; owing to the lower level, which is not considered and allowed for in the above estimate, and to a less obstructed rotation of the storm, on reaching the Atlantic.*

Moreover, the barometric minimum was observed at Quebec about as early, on the 21st, as at New York and its vicinity; although 420 miles further to the north, and nearly on the same meridian. This more rapid advance of the central portion of the storm, which has been seen in other cases, proves that the true course of progression was on the general route which I have indicated. The rate of the storm's progression, from noon of 20th to noon of 21st, I estimate at about 33 miles an hour.

It is true, however, that Prof. Loomis has traced this storm *eastward*, from the Mississippi to the Atlantic; and has stated, also, that in this case "there was no whirlwind." But, not rejecting his claims as a cyclonologist, I may state that he had almost no observations other than from the right side of the storm's center-path. Now, in like limited manner, and *with like directions and changes of the wind*, the great hurricane of September last, which we have just considered, may be traced eastward from its center-path, for a greater distance, and in the same latitudes, as already shown. The like is also true of the great Cuba hurricane of 1844, which was examined in this Journal:† as also, of Col. Reid's hurricane which crossed Bermuda and Newfoundland, in Sept. 1839, (see Chart,) on perhaps the most northerly course that has been traced in any storm.

Yet, who that duly examines these cases, will doubt that these storms, in their essential character, were great whirlwinds, moving northward and eastward? Indeed, the same or like phenomena may be traced in every great cyclone that passes over these latitudes. This eastward extension appears due, in part, to the enlargement of the cyclone; and while affecting its external form, and that of the lines of equal pressure, it does not essentially change the rotative movement; as may be seen by the continued development of the cyclonic winds, and their influence on the barometer.

It is well known that other and similar tracings from west to east have been made of the progress of various storms in the

* The extreme range of the barometer in a period of seven years at Hudson, O., near to Twinsburg, and about 1100 feet above tide, as given by Prof. Loomis, is 1·719 in.: while the range observed in New York during the same period, was 2·25 in. Difference, ·531. The mean of the annual ranges at Hudson during the same period appear to have been 1·402 in: while the mean of the annual ranges at New York was 1·874 in. Difference, ·472 in. It appears, therefore, that near half an inch should be added to the depression of the barometer in some of the western observations of this storm, in order to a fair comparison of the barometric indications with those on the Atlantic border in the same storm.

† This Journal, vols. i, and ii, New Series, 1846.

United States. It is believed, however, that the clew to these cases is already afforded; and that many or most of these storms were true cyclones; with orbital courses really analogous to those which are seen on the Chart.

What are Cyclones?—The term Cyclone was first proposed by Mr. Piddington, to designate any considerable extent or area of wind which exhibits *a turning or revolving motion;* without regard to its varying velocity, or to the different names which are often applied to such winds. If used in this sense it may prevent the confusion which often results from other names, more variable or indeterminate in their signification. Thus, all hurricanes or violent storms may perhaps be considered as cyclones or revolving winds. But it by no means follows that all cyclones are either hurricanes, gales, or storms. For the word is not designed to express the degree of activity or force, which may be manifested in the moving disk or stratum of rotating atmosphere to which it is applied. It often designates light and feeble winds, as well as those which are strong and violent.*

It follows that the local directions and changes of the wind in any cyclone, and their effect on the barometer, are much like those exhibited in the gales and storms of the same region, except in the *degree* of their effect; which is doubtless proportioned to the general activity of the rotation, integrally considered.

The cyclones are often productive of rain in a portion of the cyclonic area; but vary in this respect, in different regions, and at different seasons of the year.

Universality of Cyclones.—As early as 1833 my inquiries led me to announce the conclusion that the ordinary routine of the winds and weather in these latitudes often corresponds to the phases which are exhibited in the revolving storms, already de-

* As regards the temperate latitudes of the northern hemisphere, the true normal wind is commonly from the southwestern quarter of the horizon; and the accession of a cyclone, except on its right margin, is usually marked by a change of the wind from the western board to some point on the eastern side of the meridian, accompanied and often preceded by a fall of the barometer. On the right margin of its path the cyclone may commence from near the southwest, in perfect continuance with the normal wind with which it here coincides. As the cyclone advances, the wind on the right of its axis-path *veers* "with the sun," or from the east towards the south and west; while on the left side of this path or line, the same cyclonic wind changes from the east to the *north.* On and near the axis-path the earlier winds of the cyclone blow *across* the line of progress, from the southeastern quarter to the northwestern, with a falling barometer; and when the axis of the cyclone has passed, its later winds are found crossing the line of progress in the opposite direction, from the northwestern quarter to the southeastern, with a rising barometer.

The true cyclonic wind may not always be found at the earth's surface, in every portion of the path of the cyclone, if its action be feeble, or subject to interruption, or to the interposition of bordering winds or cyclones. Even in stormy cyclones, irregularities of direction are often noticed at the surface; but in these cases it commonly happens that the *storm-scud,* at the elevation of a few hundred feet, exhibits locally the true direction of the cyclonic wind. But the changes of direction successively observed in the storm-scud, are commonly *in advance* of those in the lowest wind.

scribed, and that a correct opinion, founded upon this resemblance, can often be formed of the approaching changes: and that the variations of the barometer resulting from the mechanical action of circuitous winds and the larger atmospheric eddies, pertain not only to the storms, but to a large portion of the winds in these and the higher latitudes. *Vide* this Journal for October, 1833, (vol. xxv,) pages 120 and 129.

The more inert and passive cyclones which seldom gain attention, but which constantly occupy in their transit the greater portion of the earth's surface, appear to move in orbits or courses corresponding with those of the more active class which have been traced on the storm-charts; a result that will not be doubted by those who have given careful attention to this branch of inquiry. In a broad view of the case, the constant occurrence and progression of the cyclones, in various degrees of activity, constitutes the normal condition of the inferior or wind-stratum of the atmosphere, at least in the regions exterior to the trade winds of the globe; to say nothing of their prevalence in the intermediate region, where their presence is shown on some occasions by the most indubitable evidence.

At the late meeting of the American Association for the Advancement of Science, held at Cleveland, an ably elaborated paper was presented by Prof. James H. Coffin, of Easton, Pa., on the relations which exist between the direction of the wind and the rise and fall of the barometer. By a careful analysis of these effects during all seasons of the year, as observed at various places in the north temperate zone, Prof. Coffin establishes the northeastwardly progression and leftwise rotation ↺ of a continued series of cyclones, in which are developed the same local relations between the rotary action of the various winds and the movements of the barometer that are found in the several rotary storms and hurricanes which have been subject to investigation; and such in kind, though not in degree, as we have seen in the principal case already considered. Thus, if I rightly appreciate the labors of Prof. Coffin, the cyclonic character of the variable winds in the temperate latitudes, which had been inferred from special observations and an extended range of geographical inquiry, is now established by a different and wholly independent method of investigation.

The storm-paths and routes of the cyclones clearly indicate, also, the true course of the principal circulation in the lower atmosphere, on both sides of the equator. An enlarged view of these physical truths and conditions may serve to convince meteorologists and others of the necessity for a thorough revision and correction of the received views of dynamical meteorology. Such revision, I apprehend, is now imperatively required. For the constant recession from the equator of a great portion of the

lowest currents of atmosphere, as seen in the orbital courses of storms in all latitudes, and to which I have already alluded, together with the mean direction of the observed winds in the northern temperate zone, even neglecting other world-wide phenomena, may suffice to show, that the current theory or hypothesis for explaining the general winds of the globe, is essentially erroneous and defective in its application, and greatly obstructs the path of scientific inquiry.

New York, March 18, 1854.

ART. XXIII.—*Researches upon Arseniuretted and Antimoniuretted Hydrogen, and their relations to Toxicology;* by RAPHAEL NAPOLI, Royal Professor of Chemistry at Naples.

(Read before the American Association for the Advancement of Science, at Washington, May, 1854, by T. S. Hunt, for the author.)

AFTER Lassaigne had observed that nitrate of silver decomposes arseniuretted hydrogen with the formation of arsenious acid, and the separation of metallic silver, Jacquelain proposed the chlorid of gold for the same object, and Berzelius in his *Traité de Chimie* says of this gas, "It precipitates the precious metals, as gold and silver, from their solutions, and is itself dissolved by the oxydation of its elements." Such a decomposition really takes place with arseniuretted hydrogen and the ter-chlorid of gold, and also with the ferric and platinic chlorids; still no chemist, so far as I know, has explained the reaction.

The explanation which I now propose was suggested to me by M. Nicolo Prestandrea of Messina, who wrote to me as follows; —"When arseniuretted hydrogen is passed through a solution of chlorid of gold, we see that the gold is really reduced, and the arsenic dissolved as arsenious or arsenic acid. But as these bodies contain no oxygen, whence comes this element to oxydize the arsenic, unless from the decomposition of the water of the solution, whose hydrogen at the same time forms hydrochloric acid, with the chlorine of the gold salt? This acid might be formed from the union of this chlorine with the hydrogen of the gaseous arseniuret, without any decomposition of water, in which case both gold and arsenic, should be separated in the metallic state, according to the following equation,

$$AuCl_3 + AsH_3 = 3HCl + Au + As.$$

So that the theory of this reaction is not yet made clear. In order to explain the facts just mentioned we must suppose that arsenic, in its nascent state at least, can be dissolved by hydrochloric acid; such being the case, it would be easy to understand the formation of the acids of arsenic, the precipitation of the gold,

and the production of hydrochloric acid. The gold having been reduced, according to the formula just given, there remains 3HCl, and As, which would yield $AsCl_3$, and three equivalents of free hydrogen. The chlorid of arsenic when diluted with a large quantity of water, is decomposed into arsenious and hydrochloric acids."

On consulting Berzelius and other works of authority, I found it stated on the one hand, that arseniuretted hydrogen is not altered by hydrochloric acid, and on the other, that arsenic is not affected by hydrochloric acid. These statements seemed to render the proposed explanation inadmissible, but I have found by experiment that they are incorrect, and have arrived at the following conclusions, first, arseniuretted hydrogen is almost totally decomposed by pure concentrated hydrochloric acid, and secondly, arsenic itself is soluble in this acid.

I passed the arseniuretted hydrogen gas generated in Marsh's apparatus, through concentrated hydrochloric acid in a Liebig's bulb tube, and after continuing the process for an hour, chlorid of arsenic was found dissolved in the acid, thus proving the decomposition of the arseniuretted hydrogen.* To prove the second point I took some crystallized metallic arsenic, washed it repeatedly with cold and pure hydrochloric acid, and when its surface was perfectly free from oxyd, attacked it with boiling hydrochloric acid in a small retort, placing a little water in the receiver. On collecting the portion which distilled over, I found it to contain chlorid of arsenic, and the liquid residuum in the retort, contained a notable portion of the same chlorid; thus showing the solubility of arsenic in hydrochloric acid.

These facts, being well established by a series of repeated experiments, gave me an explanation of the reactions of arseniuretted hydrogen on the perchlorids of gold and iron, and the bichlorid of platinum; the formulæ are as follows:

$$AuCl_3 + AsH_3 = Au + AsCl_3 + H_3.$$
$$3Fe_2Cl_3 + AsH_3 = 6FeCl + AsCl_3 + H_3.$$
$$3PtCl_2 + 2AsH_3 = Pt_3 + 2AsCl_3 + H_6.$$

While studying the above reactions, I had occasion to repeat some observations which were made long since by Stromeyer, and appear to have been forgotten by chemists, but which serve to render more accurate the examinations for arsenic and antimony by Marsh's apparatus. The facts are these: arseniuretted and antimoniuretted hydrogen are both decomposed by pure and

* The decomposition of arseniuretted hydrogen with hydrochloric acid, is represented by $AsH_3 + 3HCl = AsCl_3 + 3H_2$, and is analogous to that of hydrid of copper with the same acid; in each case a metallic chlorid is formed, and the hydrogen of both compounds is set free. See Brodie's remarks on the latter reaction, in the Chemical Gazette for 1858, p. 300.—(T. S. H.)

highly concentrated nitric acid, the former yielding water, nitrous vapor, and soluble arsenic acid, while the latter gives insoluble antimonic acid, causing a turbidness in the liquid, which is increased by concentration. If then we pass a mixture of these two gases into nitric acid, and afterwards boil the turbid solution, a yellowish-white precipitate of antimonic acid separates, and by adding water and continuing the ebullition, the antimony is entirely thrown down, while the arsenic acid remains dissolved.

The two gases are also decomposed by aqua-regia, with the formation of chlorid of arsenic, and perchlorid of antimony. By a careful distillation of the mixture, the arsenical chlorid passes over first, while the chlorid of antimony remains in the retort, as has been shown by Malaguti and Sarzau. An analogous reaction is produced with strong hydrochloric acid, but with this difference that the arseniuretted hydrogen is almost entirely decomposed, while the antimonial gas undergoes a less complete decomposition.

The applicability of these reactions to the concentration and separation of the arsenic and antimony, in the gas obtained by Marsh's apparatus, will now be apparent. Instead of burning or decomposing by heat, the evolved gas, it is passed through a U tube to dry it, and then by means of a caoutchouc connector into a Liebig's bulb apparatus, containing concentrated, fuming nitric acid, which is to be heated by immersion in a bath of water or oil. Having assured ourselves of the purity of the gas evolved by the zinc and sulphuric acid, we add the suspected matter, and then pass the gas into the hot nitric acid, which completely decomposes in the manner just described, any compounds of arsenic or antimony which may be evolved. If the nitric acid remains clear, we are almost sure of the absence of antimony. When the operation is finished, the contents of the bulbs are to be transferred to a small flask, the apparatus washed out with a little nitric acid, and the whole carefully evaporated to one-half. If there is no precipitate, the absence of antimony is certain; we then evaporate still further to remove the excess of acid, dilute the residue with water and examine it like a pure solution of arsenic acid. Should the nitric acid appear turbid either before or after evaporation, antimony is present, and perhaps arsenic; in this case, after evaporating as before to a small bulk, we add water and filter, the antimony remains behind in an insoluble condition, while the arsenic, if any were present, is held in solution, and both can be examined by the ordinary tests.

In the case of a mixture of arsenic and antimony we may proceed in a different manner for their separation. Having prepared a small tubulated retort, to which can be adapted a small receiver, we introduce through the tubulure, a tube reaching nearly to the bottom of the retort, in which is placed a small quantity

of aqua-regia composed of two parts of hydrochloric and one of nitric acid. The retort being gently heated, the gases from Marsh's apparatus are passed in a slow current into the aqua-regia. In the reaction which takes place, any arseniuretted or antimoniuretted hydrogen will be decomposed, and chlorid of arsenic or antimony formed. This operation finished, the tube is removed, the tubulure closed, and the receiver, partly filled with water, being attached, the acid liquid in the retort is gently distilled to one-half its volume. We then examine the water of the recipient, and if any arsenic is present, it will be found in the distilled liquid; if this metal be absent, we find nothing in the water, or at most, some traces of antimony, in case the operation has not been well conducted. If the gas contained any antimony, it will all be found in the retort, in the state of perchlorid.

I have not deemed it necessary to present the numerical results, which in repeated experiments have shown the great accuracy of these methods, but believing that chemists will at once recognize the value of the proposed processes, it is sufficient for me to have called their attention to the following facts, in part already known, and in part new.

1st. The power of hydrochloric acid to dissolve and decompose arseniuretted hydrogen.

2d. The solubility of metallic arsenic in the same acid, when concentrated.

3d. The explanation of the reactions of arseniuretted hydrogen, with the perchlorids of gold and iron, and with the bichlorid of platinum.

4th. The decomposition of arseniuretted and antimoniuretted hydrogen by nitric acid, and by aqua-regia.

5th. The application of these reactions to toxicological analysis, for the detection and separation of arsenic and antimony.

Art. XXIV.—*On some of the Crystalline Limestones of North America;* by T. S. Hunt, of the Geological Commission of Canada.

(An Abstract of a paper read before the American Association for the Advancement of Science, at Washington, April, 1854.)

The crystalline limestones of Canada, with those of New York and the New England States, may be divided into four classes, belonging to as many different geological periods. The first and most ancient occur in that system of rocks, named by Mr. Logan the Laurentian series, which extending from Labrador to Lake Huron, forms the northern boundary of the Silurian system of Canada and the United States. The lowest beds of the Silurian

repose horizontally upon the disturbed strata of this oldest American system, a southern prolongation of which crosses the Ottaway near Bytown, and the St. Lawrence at the Thousand Isles, and spreading out, forms the mountainous region of northern New York. This series consists in large part of a gneiss, which is often garnetiferous; but beds of mica slate, quartz and garnet rock, hornblende slate and hornblendic gneiss are also met with, besides large masses of a coarsely crystalline, often porphyritic rock, consisting chiefly of a lime and soda feldspar, which is sometimes labradorite, and at others andesine, or some related species, and is generally associated with hypersthene. It often holds beds or masses of titaniferous iron ore, and from its extent, occupies a conspicuous place in the series. It is the *hypersthene rock* of McCulloch and Emmons.

With these, the limestones are interstratified, but their relations to the formation have not yet been fully made out. All of these rocks bear evidences in their structure, that they are of sedimentary origin, and are really stratified deposits, but their investigation is rendered difficult by the greatly disturbed state of the whole formation. Among these stratified rocks, there are however dykes, veins, and masses of trap, granite and syenite, often of considerable extent, which are undoubtedly intrusive. There are abundant evidences that the agencies which have given to the strata, their present crystalline condition, have been such as to render the limestone almost liquid, and to subject it at the same time to great pressure, so that in many cases it has flowed around and among the broken and often distorted fragments of the accompanying silicious strata, as if it had been an injected hypogene rock.

The limestone strata are from two or three feet to several hundred feet in thickness, and often present a succession of thin beds, divided by feldspathic or silicious layers, the latter being sometimes a conglomerate of quartz pebbles and silicious sand; in one instance, similar pebbles are contained in a base of dolomite. Beds frequently occur in which the carbonate of lime has been mixed with silicious sand, in some cases yielding an arenaceous limestone, while in others, a chemical union has produced beds of tabular spar, often passing into pyroxene from an admixture of magnesia. These minerals sometimes form beds, in a nearly pure state, but in other cases they are intermixed with quartz, carbonate of lime, orthoclase, scapolite, sphene and other species.

The limestones are sometimes coarsely crystalline, at others finely granular or almost compact; their color is white passing into reddish, bluish, and grayish tints, which are often arranged in bands coincident with the stratification. Some of the dark grey bands, harder than the adjacent white limestone, were found by Mr. Murray to owe their color to very finely disseminated

plumbago, and their hardness to intermingled grains of rounded silicious sand. The limestone is often magnesian, and the manner in which the beds of dolomite are interstratified with the pure limestone, is such as to lead us to suppose that some of the original sedimentary deposits contained the two carbonates, and that the dolomite is not the result of any subsequent process.

The principal mineral species found in these limestones are apatite, serpentine, phlogopite, scapolite, orthoclase, pyroxene, wollastonite, idocrase, garnet, brown tourmaline, chondrodite, spinel, corundum, zircon, sphene and graphite. All of these appear to belong to the stratification, and the chondrodite and graphite especially, are seen running in bands parallel to the bedding. Magnetic iron ore is sometimes found in beds interstratified with the limestone. The apatite which is in general sparingly distributed, is occasionally very abundant in imperfect crystals and irregular crystalline masses, giving to small beds of the limestone the aspect of a conglomerate. Some of the coarsely crystalline varieties of this limestone give a very fetid odor when bruised.

In some parts of this formation, in the rear of the bay of Quinté, the rocks are less altered than in most other places, and here the limestones, although more or less crystalline in texture, afford none of the fine crystallized species elsewhere met with. The foreign ingredients seem to be mechanically intermixed, giving an earthy appearance to the weathered surface of the rock, or are separated in the form of small grains of pyroxene, showing an imperfect metamorphism. For further descriptions of the rocks of this series, see the Reports of the Geological Survey of Canada, particularly that of Mr. Logan for 1846, and Mr. Murray's for 1853; also Dr. Emmons's Report on the Northern District of New York. In position and in lithological characters, the Laurentian series appears to correspond to the old gneiss formation of Lapland, Finland and Scandinavia.

In the second class we include the crystalline limestones of western New England, and their continuation in southeastern New York, and the adjacent parts of New Jersey and Pennsylvania. The limestones of the Champlain division of the Lower Silurian rocks which are found on the Yamaska River, enter Vermont near Misisquoi Bay, where they show a commencement of alteration. Farther south, they become the white granular marbles of western Vermont, and of Berkshire, Massachusetts, which according to Hall, still exhibit upon their weathered surfaces, the fossils of the Trenton limestone; thence passing southwest, they cross the Hudson near West Point, and appear in Orange and Rockland counties, New York, and in Sussex county, New Jersey, in a highly altered condition, closely resembling the crystalline limestones of the Laurentian series, and containing in great abundance the same imbedded minerals. These limestones are some-

times dolomitic, and Hitchcock observes that in the granular marbles of Berkshire, pure and magnesian limestones occasionally form different layers in the same bed. (Geology of Massachusetts, p. 84.)

In Orange county, according to Mather, it is easy to trace the transition from the unaltered blue and gray fossiliferous limestones of the Champlain division, (including the Calciferous sandrock and the Trenton,) to the highly crystalline white limestone with its characteristic minerals. (See his Report on the Geology of the first district of New York, pp. 465 and 486.) This view is fully sustained by H. D. Rogers in his description of the limestones of Sussex Co., given in his final report on New Jersey, (cited by Mather as above, p. 468 et seq.) Mather farther concludes very justly that all the limestones of western Vermont, Massachusetts and Connecticut, and those between the latter state and the Hudson River, are in like manner altered Lower Silurian strata. (p. 464.) From the similarity of mineral characters, he moreover supposes that the crystalline limestones about Lake George are of the same age, and he extends this view to those of St. Lawrence County. Both of these however belong to the Laurentian series, and are distinguished by their want of conformity with the Champlain division, and by their association with labradorite and hypersthene rocks which seem to be wanting in the altered Silurian strata. The slates of this division in Eastern Canada, generally contain some magnesia, with very little lime, and four or five per cent. of alkalies, chiefly potash;* hence the feldspar which has resulted from their metamorphosis is generally orthoclase, and they have yielded gneiss, and mica slate, which with quartz rock, and chloritic and talcose slates, make up the Green Mountains.

In the upper part of the Champlain division, there are found some beds of a limestone, often conglomerate, which is generally magnesian and ferruginous, and often contains a great deal of silicious sand; and associated with it are beds of carbonate of magnesia without a trace of lime, though sometimes very silicious. These beds are interstratified with slates and sandstones, and in the metamorphic region are replaced by the serpentines, which are often intermixed or associated with limestones and dolomites, and, with their accompanying talcose slates, may be traced one hundred and thirty-five miles in Canada, and thence by Vermont, Massachusetts and Connecticut, through New York, New Jersey, Pennsylvania and Maryland, southward. These rocks are everywhere marked by the occurrence of chromic iron ore, in masses running with the stratification, or in disseminated grains, in the serpentine, and sometimes in the dolomite; they are also the

* See my remarks On the Composition and Metamorphoses of some Sedimentary Rocks, L. E. and D. Philos. Magazine for April, 1854, p. 233.

auriferous rocks of the great Appalachian chain. Gold, associated with talcose slates, serpentine, chromic and titaniferous iron ores, is traceable along their outcrop from Canada to Georgia. Gold-bearing veins have also been found in the slates which in Eastern Canada, form the base of the Upper Silurian. I remark that in a somewhat chloritic and very silicious magnesian limestone, which is associated at Granby with red and green slates and sandstones, a portion of oxyd of chromium was detected by analysis. I have also found titanium in some of the very ferruginous slates, which by their alteration become chloritic schists holding magnetic and specular iron, ilmenite and rutile.

Serpentine is found as an imbedded mineral in the Laurentian limestones, but the extensive deposits of serpentine rock, with its associated talcose slates and chromic iron, appear to be confined to the upper part of the altered Champlain division. The examinations of C. U. Shepard, and those subsequent of J. Lawrence Smith and G. J. Brush, have shown that many at least of the so-called serpentine rocks of northern New York, are hydrous silicates of alumina, iron, and potash, containing very little lime or magnesia; they are the dysyntribite of Shepard.

As the northwestern limit of the metamorphic belt in Eastern Canada runs southwesterly into Vermont, the undulations of the strata, which are nearly N. and S., escape from it to the northward. Proceeding E. S. E. however, from the unaltered Trenton limestones of the Yamaska, we cross the overlying slates, sandstones and dolomites, and entering the metamorphic region find the serpentines, talcose, chloritic and micaceous schist, with gneiss and quartzite, very much disturbed, and repeated by undulations. On reaching the valley of Lake Memphramagog, we come upon the third class of crystalline limestones, which are Upper Silurian. This limestone formation has a continuous outcrop from the Connecticut valley, by the lake just mentioned and the upper part of the St. Francis river, to the Chaudière, and is thence traceable by intervals as far as Gaspé, where it is clearly unconformable with the Lower Silurian. It holds the characteristic fossils of the Niagara group, but for some distance from the line of Vermont, is so much altered as to be white and crystalline, and to contain abundance of brownish mica, the fossils being often obliterated. At Dudswell on the St. Francis, the beds of white granular marble show upon their weathered surfaces or in polished sections, the forms of encrinal discs and corals, among which the characteristic *Favosites gothlandica*, and various species of *Porites* and *Cyathophyllum*, have been identified. These fossils in a similar condition are also found at Georgeville on Lake Memphramagog. Following the section in a S. E. direction, to Canaan on the Connecticut river, we meet with calcareo-micaceous schists, which are gradually replaced by mica slates with quartzose beds.

Some of the fine dark-colored mica-slates exhibit crystals of chiastolite, and others near Canaan, abound with black hornblende and small garnets. (For the details of this section see Mr. Logan's Report for 1847–48.)*

These Upper Silurian strata constitute the micaceo-calcareous rocks of Vermont, which Prof. Adams traced through the state, to Halifax on the border of Massachusetts, and they are continued in what Hitchcock has called the micaceous limestones of this state, which according to him pass by insensible degrees into mica slate. The limestones of Coleraine, Ashfield, Deerfield and Whately, Mass., belong to this formation, and perhaps also the crystalline limestone which is found at Bernardston, with magnetic iron and quartz rock, and shows imperfect fossils upon its weathered surfaces. (Hitchcock's Geol. of Mass. p. 560.) The condition of these limestones resembles that of the granular marbles on the other side of the Green Mountains, and they nowhere exhibit that degree of alteration which distinguishes the latter farther south. The same calcareo-micaceous rocks are conspicuous in western Connecticut; but in the towns of Salisbury, Sharon and Canaan the crystalline limestones, and in Litchfield and Winchester, the serpentines, of the Lower Silurian are met with, and these rocks appear again in the southwestern part of the state.

In the fourth class we include the crystalline limestone of eastern Massachusetts, which occurs in a great number of places in the towns of Bolton, Boxborough, Chelmsford, Carlisle, Littleton, Acton, Natick and Sherburne. It appears according to Hitchcock, in interrupted lenticular masses, lying in the gneissoid formation, or in the hornblendic slates, and occasionally presenting distinct marks of stratification. Still farther east at Stoneham and Newbury, we find crystalline limestone, sometimes magnesian, in irregular masses, lying in a rock intermediate between syenite and hornblende slate. Serpentine is found with that of Newbury; and at Lynnfield, a band of serpentine has been traced two or three miles N. E. and S. W. Dr. Hitchcock, to whose report on the Geology of Massachusetts we are indebted for the present details, says of this serpentine, "I am satisfied that it is embraced in the great gneiss formation, whose strata run from N. E. to S. W. across the state." p. 159. He further remarks of the syenite of Newbury and Stoneham, which includes the crystalline limestones, "I have every reason to believe that it is only a portion of a gneiss formation which has undergone fusion to a great degree; for portions of the rock still retain a slaty or stratified structure," and he conceives it probable that all the crystalline limestones of Massachusetts are of sedimentary origin; p. 586. It may be remarked that the irregular shape of these interstratified

* See also on the Geology of Canada, this Journal [2] vol. ix, p. 12, and xiv, p. 224.

masses, is analogous to the interrupted stratification and lenticular beds, frequently met with in fossiliferous limestones.

The limestones of Bolton, Chelmsford and the adjoining towns, are in general highly crystalline, and are remarkable for the variety of fine crystallized minerals which they contain. Among these are apatite, serpentine, amianthus, talc, scapolite, pyroxene, petalite, chondrodite, spinel, cinnamon-stone, sphene and allanite, which include the species characterizing the Laurentian and Lower Silurian metamorphic limestones. The limestone of these quarries evolves a very fetid odor when bruised. Chromic iron ore has never, so far as I am aware, been observed with the serpentines of this region.

We have now to inquire as to the geological age of this great mass of crystalline rocks which is so conspicuous in Eastern New England. Mr. Logan has shown that the rocks of the Devonian System in Gaspé, assuming the Oriskany sandstone as its base, attain a thickness of more than 7000 feet, and as they are still 2500 feet thick in New York, and do not die away before reaching the Mississippi, it is to be expected "that they would follow the Upper Silurian zone in its southwestern course from the eastern extremity of Gaspé, and display a conspicuous figure either in a metamorphic or unaltered condition, between it and the carboniferous areas of Eastern America; to one of which New Brunswick belongs, while another is met with in the state of Rhode Island, and in a metamorphic condition in Massachusetts." (Report for 1848, p. 58.) The lower part of the Devonian, farther west embraces beds of limestone, but in Gaspé the formation consists almost entirely of siliceous and argillaceous beds; in Mr. Logan's section of the whole 7000 feet on the Gulf of the St. Lawrence, he observed only one small bed of limestone, and a few thin bands of limestone conglomerate. When we consider the geographical position of the Upper Silurian rocks in the Connecticut valley on the one hand, and the coal field of southeastern Massachusetts on the other, we can scarcely doubt that the intermediate gneissoid, and hornblendic rocks, with their accompanying limestones, are the Devonian strata in an altered condition. Prof. Agassiz, from his own examination of the region, was led to a similar conclusion as to the age of the so-called syenites, and in August, 1850, presented to the American Association for the Advancement of Science at New Haven, a paper on the Age of the Metamorphic rocks of Eastern Massachusetts, which has never I believe been published. The less altered limestones which, according to Dr. Hitchcock are found interstratified with red slates at Attleborough and Walpole, may correspond to those which with similar slates and sandstone, are met with at the base of the carboniferous formation in Canada on the Bay de Chaleurs, and in New Brunswick.

We have then distinguished four classes of crystalline limestones: first, those of the Laurentian series with their accompanying garnetiferous gneiss, labradorite and hypersthene rocks; secondly, those of the Lower Silurian formation, with their attendant auriferous rocks, talcose slates and chromiferous serpentines; thirdly, those of the Upper Silurian age, with their associated calcareo-micaceous schists; and fourthly, those which belong to the gneissoid rocks of eastern Massachusetts, and are probably of the Devonian period.

I have endeavored in this paper to bring together the facts known with regard to the different crystalline limestones, and their associated strata in this portion of the continent, and to show how far these may serve as a guide in the geological investigation of the metamorphic rocks. While the result confirms the observations of European Geologists, that similar crystallized minerals may occur in the metamorphic limestones of very different geological epochs; it also shows, that within certain limits, the mineral characters of the altered silicious strata, may serve as important guides to our investigations.

Art. XXV.—*Documentary Publications and Science in the Coast Survey Report for* 1853.*

Congressional printing is no longer beneath criticism. It had reached such a depth of degradation in respect to paper, type, proof-reading, press-work, binding and unpunctual delivery, that not even the long suffering of Congress could further endure its vexations and malpractices, however serviceable these might be thought to a party or pet contractor. From Faustus to Little & Brown's last imprint, typography could scarcely show worse specimens than some of the Congressional contract documents, from the Mexican war dispatches to the reorganization of the public printing, about two years since. The chief provisions of the law of reorganization are, one for the election of the same or separate public printers by the Senate and House, the rates and style being carefully defined in the law; one, instituting a responsible superintendent of public printing, appointed by the President, whose business it is to make sure of the proper execution of all printing ordered, in respect to manner, time and quality; and finally, one, directing that a general contract be made for the supply of all the document and bill paper used in public printing, this contract being made by the superintendent, who is also re-

* Report of the Superintendent of the Coast Survey, showing the progress of the Survey during the year 1853. Washington, D.C. Robert Armstrong Public Printer. 1854. Quarto Report, 88 pp. Appendix, 180 pp. Total pages 276 and 54 sketches.

sponsible for its proper fulfillment. The whole efficiency of this system is dependent on the capacity and integrity of the superintendent of public printing, who should be not only an honest man, but a man of administrative capacity and of technical acquaintance with the details of printing, a judge of the quality of paper, a critic of engraving and of the varieties of engraved prints, and a thorough proficient in the printing usages of Congress. This appointment has thus far, we believe, fallen into good hands, and to this, with the praiseworthy seconding of the public printer, we are bound to ascribe most of that conspicuous improvement in all typographical elements so observable in the Congressional documents of the last two sessions. The plan of furnishing inspected contract paper to the printers instead of permitting them to impose on Congress whatever trash they might choose, has proved a capital hit, and will work admirably so long as the contracts are rightly awarded and the contractors held rigidly to the bond. To the recipients of Congressional documents it is so great a blessing to have them decently executed, as certainly they now are in respect to paper and printing, that the recent renovation seems worthy of distinct critical acknowledgment and public congratulation. Unfortunately, such congratulation must stop short of documentary binding, which is still the victim of a wretched system, poorly administered. Indeed, nothing less than a national bindery, a superintendent of binding or the bestowal of the functions of such an office, with a binding assistant, on the printing superintendent, would seem adequate to the cure of existing abuses.

To men of science, Congressional documents are rapidly growing in interest. Much important scientific matter now sees the light in this and only this form. A large portion of the researches, investigations and explorations of the country, are in some wise so related to the general government, as to find their fitting place in the immense series of Executive documents and reports of committees. If to these be added the scientific publications of the State governments, it is really quite surprising to observe how large a portion of the labors of our scientific men are published through these channels. This is doubtless a natural result of the great preponderance of descriptive research and science in a country so unexplored as ours, and in which for that reason, natural history, botany, mineralogy, descriptive geology, geography and meteorology, rightly occupy leading places, and specially enlist governmental patronage. For a time, general and abstract researches will, and legitimately may, give place to the labors of the literal historiographer of nature, though this discrimination ought on no account to survive the occasion for it.

Most of the descriptive science published by Congress has been in connection with the various expedition reports by the

government officers employed from time to time in exploring our western territory, and those from foreign shores, important to our commerce though too little known. Investigations into the botany, natural history, geology, meteorology, topography and agricultural capacities of the various sections explored, have formed integral and essential parts of these explorations, and of course their results have been duly incorporated into the several reports. From Lewis and Clark, Long and Nicollet, down to the present time, these expedition reports have been growing in number, interest and value. The explorations of Wilkes, Fremont, Abeel, Pope, Peck, Cook, Whiting, Miehler, Simpson, Cross, Sitgreaves, Stansbury and Gunnison, Marcy and McClellan, Emory, Whipple, Williamson, Evans, Stevens and McClellan, have been or soon will be formally reported to Congress, and together they constitute a large part of the reliable information now published on our immense western and southwestern territory. In addition to these have been or soon will be published on foreign countries, the Wilkes Exploring Expedition narrative, maps, and scientific descriptive volumes, Lynch's Dead Sea, De Haven's Arctic exploration report, Herndon's and Gibbon's Amazon reports, the reports and results of Gillis's Astronomical expedition to Chili, the reports of the Japan expedition, Ringgold's North Pacific expedition, Page's La Plata exploration, an African exploration, &c. Add to these Foster and Whitney's Reports on mineral lands, Owen's Geological Report, Schoolcraft's Indian publications, the Census Reports, the Patent Office Reports, the Coast Survey Reports, the Smithsonian Reports, and the multitude of less pretending reports on scientific subjects (such as the Capitol extension, building stone experiments, Espy's reports, boiler explosion reports, on anæsthetic agents, &c.) embraced in the file of Executive documents and reports of committees: the resulting aggregate of matter possessing scientific value thus published by Congress, far exceeds our natural anticipation both as to amount and importance.

Unfortunately, the scientific value of materials published in the documentary series, whether of Congress or of State legislatures, is very much impaired by the unsystematic and injudicious plan *of distribution* actually pursued. Men of science to whom particular reports would be of direct practical use, are often entirely unable to procure copies of them, while many men of more political importance, but who will never even look into them, have these same reports profusely lavished upon them. Valuable documents which are reported to applicants as all exhausted, do wholesale duty as wrapping paper for Washington grocers and market men, at a standard price of four cents a pound, maps and plates included. This subject of documentary distribution deserves the serious attention of Congress, and it would not seem

a vain hope that some system could be devised which would be indefinitely superior to that now prevailing, as well in respect to securing rigid responsibility for documents as property, and in promoting the economy, order and convenience of their practical distribution, as in the more important point of securing something like fitness in sending special documents to their appropriate recipients. Distributing Owen's Geological Report to a dry goods importer and the Treasury report on commerce to a geologist, would seem too great an absurdity to exist if we did not know that hundreds of truly valuable volumes are annually thus wasted. This place is not the fitting one for a full discussion of this subject, but it does seem specially appropriate here to state, that a general wish certainly prevails among our scientific men, for the speedy adoption of some system whereby each actual investigator can be regularly and certainly furnished with the exact documents he needs. To purchase these works at regular publishers prices, would be on the whole better for them, despite their notorious brevity of purse, than the present system of lottery distribution; but save in a few exceptional cases, regular purchase is impracticable. The British system of publishing parliamentary documents at moderate fixed prices, would undoubtedly be more acceptable to cultivators of science than the existing chaotic practice which sends away the larger portion of Congressional and State reports on scientific matters. In half the instances, a report when needed is not now obtained at all, either by application or purchase, and when purchased, it is almost always at an exorbitant price. This whole subject deserves consideration and reforming action.

We believe that the printing orders of Congress will enable the Superintendent of the Coast Survey to send copies of his Report for 1853 to the active cultivators of science and such other persons as would find it of real utility, application being duly made to him in Washington, with the name, address, occupation and special scientific or practical pursuits of the applicant. From this Report we will now abstract in a few pages the points of chief scientific interest embraced. Having been favored with the sheets in advance of binding, we are enabled to make this abstract in anticipation of the actual distribution of copies, which probably will not begin until sometime subsequent to the appearance of this article.

The Coast Survey has now reached a very regular rate of annual progress, and its operations during 1853 extended into each of the eleven Coast Survey sections constituting the entire United States coast. The progress of reconnoissance, triangulation, topography and hydrography during the year, has been very satisfactory, being much the same as during the previous year: on

this, there is no occasion for present remarks. In proceeding to give an abstract of science in the Report of 1853, we may advantageously make use of the following heads. 1. *Gulf Stream explorations;* 2. *Tides and tide gauges;* 3. *Longitude operations;* 4. *Geographical positions;* 5. *Map projection tables and notes;* 6. *Publishing records and observations;* 7. *Miscellaneous.* The remaining subject matter of the report lacks purely scientific interest, and could scarcely be abstracted. The details of field and office operations, the examinations of light house sites, the lists of parties, &c. are given with the customary fullness, constituting a thoroughly digested record of the year's operations.

Gulf Stream exploration.—This great and singular peculiarity, embracing in its mighty sweep our entire Atlantic offshore vicinage, is so important to navigation and so essential a feature of our coast hydrography, both in its practical and scientific character, that its thorough exploration ought certainly to form an integral part of the Coast Survey, whence our offshore charts are all to be derived. A specific and complete delineation and theory of this unique oceanic movement can only be reached as a result of elaborate and continued observations on all its physical and phenominal elements. This giant problem is thrown down as a gage at our national door, and the honor code of philosophic chivalry bids us accept the challenge. With a clear perception of the requirements of this great research, Prof. Bache in 1845 organized and began the execution of a plan of operations, which provided for running a system of perpendicular sections across the axis of the stream from selected points of the coast and observing at frequent stations along these sections, the several elements required. Between 1845 and 1848, sections were run from Montauk Point, Sandy Hook, Cape Henlopen, Cape Henry and Cape Hatteras; when from accidents and other hindrances, the work was intermitted until in 1853, when sections were run from Cape Hatteras, Cape Fear, Charleston, St. Simons, St. Augustine and Cape Canaveral. The results for 1853 are given in a sketch of detailed sections, and a general delineation of the Gulf Stream in its several component bands or threads, as thus far determined, will be found among the sketches. Over six pages of the Report are devoted to a full exposition of the results already reached.

The element of temperature, superficial and at various depths, has been chiefly observed, up to this time; the instruments used being Six's registering thermometer for moderate depths and Saxton's metallic deep-sea thermometer for the greater depths, a temperature sounding of 2160 fathoms having been made. One general result of the investigation is that "there are alternations

of temperature across the Gulf Stream, cold water intruding and dividing the warm, making thus alternate streaks or streams of warm and cold water. In fact, the Gulf Stream is merely one of a number of bands of warm water separated by cold water." A "cold wall" limiting the Gulf Stream on the shore side, is clearly made out, as also its slight shoreward slope from the warm water overlying the cold. A distinct current of underlying cold water from the northern regions is found alike in the northern and southern sections. "It can hardly be doubted that this cold water off our southern coast may be rendered practically useful by the ingenuity of our countrymen. The bottom of the sea fourteen miles E. N. E. from Cape Florida, 450 fathoms in depth was in June, 1853, at the temperature of 49° Farenheit, while the air was 81° Farenheit. A temperature of 38° (only six degrees above the freezing point of fresh water) was found at 1050 fathoms in depth about 80 miles east of Cape Canaveral. The mean temperature of the air at St. Augustine is 69°·9 Farenheit, and for the three 57°·5. The importance of the facts above stated in reference to the natural history of the ocean in these regions, is very great, but, of course, requires to be studied in connection with other physical data. It has also a bearing upon the important problems of the tides of the coast. This exploration of the Gulf Stream will be steadily prosecuted to its close, the different problems being taken up in turn or in connexion as may be found practicable."

The most remarkable fact brought to light in relation to the Gulf Stream is probably that of the existence of two submarine ranges of hills near its origin, which produced most marked effects on the distribution of its parts. "The form of the Charleston and Canaveral sections," as shown in the diagram, shoals "gradually from the shore to 53 and 36 miles respectively, then suddenly falling off to below the depth of 600 fathoms. On the Charleston section, 96 miles from the coast is a range of hills steep on the land side and having a height of 1800 feet and a base of about eleven miles on the seaward side; a second range 136 miles from the coast, 1500 feet high, with a base of about seventeen miles, on the outer side. Beyond this there is a more gradual rise. On the Canaveral section the inner range is 68 miles from the coast." The effect of this form of the bottom in forcing up the deep cold water stratum is very marked, so that the deep isothermals of section, exhibited a general conformity to the bottom curve. It is undoubtedly due in a considerable degree to these submarine hill-ranges, and to their uplifting of the cold water, that the Gulf Stream is divided into several superficial bands, though to what exact extent and how far subject to variations remain to be studied. Horizontally, the conformity of the Gulf Stream to the coast line configuration is verified even in detail,

and its modifications by the variation of steepness in the off-shore bottom slope, are strongly marked. With these results. the names of Lieuts. Davis, George M. Bache, Richard Bache, S. P. Lee, Maffitt and Craven are conspicuously associated; George M. Bache being distinguished as a martyr to his zeal, in the very glow of talent, hope and success.

The results of the microscopic examinations of seventeen Gulf Stream bottoms made by Assist. L. F. Pourtales (Appendix No. 30), are of great interest. From these and many other investigations of bottoms, he has derived the generalization that the per-centage of shells, chiefly Foraminiferæ, progressively increases with the depth, and he remarks of a bottom from the depth of 1050 fathoms that it "is no longer sand containing Foraminiferæ, but foraminiferæ containing little or no sand. The grains of sand have to be searched for carefully under the microscope, to be noticed at all." It will be seen that this result coincides with Prof. Bailey's recent announcement, thus closely linking the Gulf Stream bottoms with those of the remoter parts of the Atlantic. Mr. Pourtales also somewhat examines the question whether these minute animals lived where they were found, or have been gradually washed down from the reefs. Though not decisive the evidence inclines him to the opinion that they lived where found. This is indicated by the fact that most of the individuals are found perfect, notwithstanding the extreme delicacy of the shells, and again by the delicate pink color of the Globigerinæ, which could scarcely survive transportation. The fact of the occurrence of the same species off the New Jersey coast and off Cuba and other West India islands under very dissimilar circumstances of light and temperature is also indicative that they are actually drawn from their true habitat in these Gulf Stream soundings. Mr. Pourtales well remarks on the importance of "a knowledge of the habitation and distribution of the Foraminiferæ" to geologists, "since of all classes of the animal kingdom, none has contributed so large a share to the formation of rocks, at least in the cretaceous and tertiary formations."

Tides and tide gauges.—It is an indispensable step in the survey of each harbor, river, bay, &c., of the coast, to make special observations on the tides; at least so far as to establish the place of reference to which the soundings shall be reduced and to have adequate tide records for effecting this reduction of each sounding. A tide table with the corrected establishment and notes descriptive of the tidal movements are parts of the engraved matter required to go on each finished chart of the Coast Survey. In the regular prosecution of this work, there thus results a great accumulation of tidal observations which require reduction and discussion before the charts can be completed. Also several permanent tide stations are established along the coast, to furnish by

their minute and continuous records the elements of wider and more critical investigations into tidal phenomena. All these observations are now regularly reduced by a special "tidal party" under the particular direction of Prof. Bache.

The Report of 1853 (Appx. No. 26) contains a very valuable table, embodying the principal reduced results at 64 important tide stations on the Atlantic, Gulf and Pacific coasts. Appendix Nos. 27, 28 and 29, contain elaborate discussions by Prof. Bache, of the tides at Key West, and Rincon Point, San Francisco, in which they are reduced and resolved into results of the physical tidal theory. The curves of the phenomena of the theoretical components are presented in three plates. Prof. Bache thus sums up the tidal peculiarities of our entire coast. (p. 7, Report.)

"It is an interesting fact that the tides of our Atlantic coast, of parts of the Gulf of Mexico, and of the Western coast, are of three different types. Those of the Atlantic coast are of the ordinary type of tides—twice in twenty-four hours—having, however, a distinct though small difference in the height and time between the morning and afternoon tides, known as the diurnal inequality. The Gulf tides are single-day tides, and, until the Coast Survey developments established the contrary, were believed to depend upon the winds which have the character of trade-winds, and, therefore, considerable regularity along that coast. The tides of our Pacific coast ebb and flow twice in twenty-four hours, but with so large a diurnal irregularity in height that the plane of reference of mean low water, commonly used on the charts, would if employed be a snare to navigators. A rock in San Francisco bay, which at one low water of the day might be covered to the depth of three and a half feet, might at the next be awash. The observation of the tides on the Atlantic coast having been made in close connection with the other parts of the hydrography, the stations still wanting will be filled up as we advance. A few stations are still required on the Gulf of Mexico to complete the general determination of its tides from Cape Florida to the Rio Grande. We have already found nearly the dividing position, Cape St. George, Apalachicola, where the tides resemble on the one side, eastward, those of Cedar Keys, Key West and Tampa Bay, ebbing and flowing twice each day, with a large diurnal inequality, and on the other, westward, resemble the tides at Mobile entrance, the Delta of the Mississippi, Galveston and the Rio Grande entrance, ebbing and flowing, as a general rule, but once in twenty-four hours."

The Report contains a detailed description of Saxton's self-registering tide gauge (Appendix No 38. Sketch No. 54); a report of operations in establishing a tide gauge with a pipe leading seaward on a difficult open coast near Nantucket (Appendix No. 13); and finally a report of operations in obtaining off-shore or

open ocean tidal observations, on a shoal a mile and a half from land. (Appendix No. 15.) The excellent results from Saxton's gauge lead to high expectations from the records now regularly received from three permanent and three movable Saxton gauges, operating on our Western coast. The importance of separating the true tide wave from the heaping up of water along shore, leads us to watch with peculiar interest the off-shore observations and to hope for their success at much greater distance from land.

Longitude operations.—It is now esteemed essential where practicable, in conducting the survey, to refer at least one principal station in each section, to the central longitude point (Seaton station, Washington), by a telegraphic determination of longitude differences. During the year 1853, operations were conducted for thus connecting Charleston with Seaton station, the longitude difference already found by Mr. Walker in 1850, being only a preliminary determination. Such was the imperfect condition of insulation of the telegraph wires, as found by repeated trials, that it became indispensable to establish an intermediate station and Raleigh was thus occupied. Dr. B. A. Gould's report of these operations is given in Appendix No. 33. Some observations were also made on the velocity of the galvanic wave, and the personal equations of the observers were duly compared. Charleston will soon be in turn similarly connected with New Orleans.

Prof. B. Peirce reports (Appendix, No. 31) the results of his investigations and of some observations made under his charge, for the purpose of ascertaining a method of determining, "the longitude from observed transits of the moon, which shall not be involved in the great and singular errors of the lunar ephemeris." After stating the faults of the present methods, in which standard corresponding observations of moon culminations are interpolated, he concludes that as the existing lunar theory will not stand the test of observation, a correct ephemeris is not now practicable. He then, from three hundred and sixty-seven special comparisons, determines the standard probable error of an observation of a lunar transit as one-tenth of a second of time. An attempt to determine an annual empirical correction for the lunar elements failed, and gave place to the determination of a constant error of epoch and a periodical error running through a half lunation. For Greenwich observations, 1847, the probable error of ephemeris longitudes thus corrected, when compared with observation, came out very nearly the standard probable error of a transit observation. This investigation has been since continued.

Prof. W. C. Bond reports (Appendix, No. 32) the results of some operations for testing the accuracy of the spring governor records. Numerous star transits of Spica (110 are given) over the wires of the Cambridge equatorial were simultaneously recorded by two spring governors, differing one-tenth of a second

in their pendulum-vibration times: one governor was at Cambridge and the other at Haverford, Penn. The result of scrupulous comparisons of their records, indicates no discrepancy exceeding three hundredths of a second ascribable to the imperfect equalizing action of the spring attachment.

Mr. G. P. Bond has reported in considerable detail, (Appendix No. 34,) on the computations of the chronometric expeditions of 1849, '50 and '51, for determining the difference of longitude between Cambridge, Mass., and Liverpool. He details the precautions taken to ensure accurate reductions of the transit observations for local time and for evolving errors of observation. He discusses the micrometric and level division values, the azimuth and collimation errors, lateral refraction, personal equations, clock errors, the position of the midwire of the transit, the pivot figures, the errors of comparing the chronometers with the standard clock, and the irregularities of chronometer and clock rates. The general results of the computations have since been submitted to the American Association at the Washington meeting, when Prof. Peirce announced additional discussions of moon culmination longitude methods, in reference to the longitude of America. We are now near the final fixation of the standard longitude difference between our system of connected stations and that of Europe: which difference once authoritatively established, will doubtless be liable to no future change, unless by submarine telegraphic determinations.

Geographical Positions.—In the Coast Survey Report for 1851, is a list of 3240 stations, to which an addition of 600 is made in the Report of 1853, (Appendix No. 7.) For each of these 3840 stations, a latitude and longitude is given. Also for each of the lines connecting these 3840 stations, as shown in the section triangulation sketches, the length of line is given in metres, yards and miles, and its azimuth in both directions is introduced. This extensive series of geographical positions and of triangulation elements is the product of an immense labor of observation and computation, being indeed the great trigonometrical consummation of the survey up to the present time. It will prove of wide and permanent use to have easily accessible so extensive a series not only of latitudes and longitudes of stations but of accurate distances and bearings between so many intervisible points, along our entire seaboard. In numerous instances, surveyors can conveniently test their compass variations by observing on one of these lines of given azimuths. The enduring value of this list for plotting surveys and maps is self-evident and will not be impaired by the slight corrections to which some of the positions and distances will in future be liable.

The development of *station errors*, or distinct discrepancies between the geodetic and astronomical latitudes and longitudes

of particular stations, is a constantly recurring result of the survey. They are caused by local irregularities in figure and density of the earth and amount in several instances to about three seconds, while at a station of the Ordnance Survey, the station error is nine seconds. The attraction of mountains is not the usual cause of these errors, though a displacement of the vertical to a much greater amount has in some cases been traced to this origin. When it is known that even now, before the mutual verification of sections by connecting their base lines, the tabular distances given in this list are generally considered as liable only to an average error of about one foot in six miles, it will scarcely seem wonderful that the station errors are found to be as distinctly indicated by a comparison of the azimuth and back azimuth observations, as by those for latitudes and longitudes; so that the two results even verify each other quantitatively. The notes introducing the list give a clear insight into its mode of construction and arrangement.

Map projection tables and notes.—The most voluminous adjunct to this report is Appendix No. 39, giving tables for projecting maps with notes on map projections. It is much to be hoped that this valuable accession to the means of accurate map construction will accomplish something towards effecting a reform in the very imperfect chartographic practice, now too widely prevalent.

The notes present in a condensed form a classified synopsis of the various projections which have been used. The four classes into which these are distributed are based on their peculiar modes of mathematical genesis. The distinctive features of eighteen species of projections, are briefly and systematically presented. Bonne's projection, being that chiefly used in Europe for topographical surveys of considerable areas, is discussed in greater detail. Still more space is given to the *polyconic* projection, which is that used in the Coast Survey office. This name is new, and the two varieties, called *rectangular* and *equidistant* are both in use and require the same tables. Fortunately these methods can now be employed by any intelligent draftsman, furnished with this report, in constructing any local, county, state or general map, within the United States. Full instructions are given under a special head for the graphic construction of the rectangular and equidistant polyconic projections. The formulæ used for computing the tables, also the constants employed and their logarithms are given, though without the detailed derivation of the formulæ.

The Tables are six in number. Table I. gives the relation between the units of length used in different countries—Table II. has for its object to facilitate the conversion into each other of metres, yards and statute miles, and will be found highly con-

venient in many computations—Table III. gives the length, in statute and nautical miles, of a degree of the meridian for each 5° between latitudes 20° and 50°—Table IV. gives the length of a longitude degree for each degree parallel, between Latitudes 17° and 50°, expressed in nautical and statute miles and meters —Table V. gives the lengths of the parallel and meridian arcs and coördinates for projecting large maps in the United States and can be used for a map embracing the area between Latitudes 17° and 50° and extending 70° in Longitude, which limits include considerably more than the entire United States. Table VI. gives the lengths of the arcs of parallels to seconds for each minute of Latitude between 24° and 50°; it also gives the meridian arcs and coördinates with corresponding accuracy. This table is available for constructing any local map projection on a large scale, anywhere within the latitude specified. For state or general maps, Table V. should be used, and for town and country maps, &c., Table VI. is required. It will be seen that these tables suffice for all the geographer's needs within our national limits, while a little study and practice will enable any one to use them correctly and rapidly. The superiority of the projection on which these tables are based, should induce its general use for all the purposes indicated.

Publishing Coast Survey records and observations.—We observe with satisfaction that the estimate for the ensuing year, embraces an item of $20,000 for the long desired and oft recommended publication of records and observations, made in the progress of the survey. It is earnestly to be hoped that the experience of the British Ordnance Survey in relation to this class of publications will not be lost on us. Why should we wait until their day of greatest usefulness is past, until all freshness of interest has departed, before doing what must be done at last, and what ought for all positive reasons to be done now? Delay is most thriftless policy in this case, and especially as the Treasury is now plethoric with surplus revenue. The whole matter is thus clearly set forth by the Superintendent. "The history of such works shows that the observations accumulated during their progress and which must be published for permanent reference and to give them authenticity, are brought out very slowly. Those who have taken part in them are dispersed, and questions arise which require their aid to answer. However perfectly in theory a work is organized, such questions will arise. The interest in the results is lost with the responsibility for their accuracy. The present time, when the organization is complete, and the observers are still connected with the work, is the proper time, on every account to publish the observations. The economy of present publication would be very considerable. I am sustained in these views by the judgment of the scientific men of

the country generally." We certainly hope to see this work soon commenced.

Miscellaneous.—Among the operations in Maine are reported some measurements of heights by nearly all practicable modes. From these and other operations there, we see evidently looming forth "important data for the coefficient of refraction under different circumstances, and in relation to the relative advantages in accuracy, time and other particulars of the different modes of measuring heights."—At East Base near Galveston, an elaborate set of latitude and magnetic observations is reported.—The list of Coast Survey nautical discoveries and developments for the year embraces nineteen items, chiefly of shoals, rocks, banks and changes in bars, inlets and harbors. The Gulf Stream submarine hill-ranges, before mentioned, are the crowning discovery.—The 54 Sketches appended to the Report, embrace much new hydrography of importance to navigation, and among other subjects of congratulation is specially noticed, the completion of the troublesome but highly important hydrography of Nantucket Shoals.—Appendix No. 36, consists of notes on lithography and lithographic transfers. The sketches give evidence of the value of the transfer process, being all (23,000 copies from each of 54 plates) printed by its aid, without serious wear of the copper plates. The subject of adapting engraving to transfer printing is touched upon and is of much importance to such as are about using the transfer process.—Appendix No. 37, describes a novel instrument called the interranger, for enabling boats conveniently to run on range lines between opposite stations; also some account of various devices tried.—Appendix No. 35, gives the results of two analyses of deposits taken from the boiler of the steamer Hetzel. This is a subject of practical importance and it is to be hoped that some corrective may grow out of such analyses.—Appendix No. 43 will be interesting to those who feel how great a loss the country sustained in the death of Sears C. Walker.

There is much more in the various field and office operations, which might interest scientific readers, but space bids us refrain. In conclusion, we may remark, that taken as a whole, this report equals or exceeds any of its predecessors in the extent and value of its contributions to science; and that by its paper, typography, indexes and sketches, it goes far towards reasserting the admissability of a Congressional Document to respectable libraries. H.

Art. XXVI.—*On the use of Hydrogen Gas and Carbonic Acid Gas, to displace Sulphuretted Hydrogen in the analysis of Mineral Waters, &c.;* by Prof. W. B. Rogers and Prof. R. E. Rogers.

First.—On the use of *Hydrogen Gas* in the analysis of Sulphureous Waters.

One of the most difficult points in the analysis of mineral waters is the determination of the sulphur which is contained in many of them in the two conditions of Sulphuretted Hydrogen, and a sulphid, either of an alkaline metal or of magnesium or calcium. No satisfactory process has we believe yet been devised for this purpose. It is easy enough by the nitrate of silver or chlorid of copper to determine the total quantity of sulphur present in these compounds; but in the subsequent process of boiling the liquid preparatory to the precipitation of the sulphur of the sulphids, while we expel the free hydrosulphuric acid, we at the same time decompose the sulphid of magnesium or calcium which may be present, even when the process is conducted out of contact with the air, as in an atmosphere of hydrogen gas; and if we boil the liquid in the air or even expose it for some time to the atmosphere at common temperatures, the sulphids of sodium and potassium as well as of magnesium and calcium, are gradually decomposed by the carbonic acid of the air evolving their sulphur in the condition of hydrosulphuric acid. At the same time by the action of the atmospheric oxygen a portion of the alkaline sulphid is converted into hyposulphite. It is therefore desirable to discover some method of separating the free hydrosulphuric acid without at the same time affecting the other sulphur compounds present in the water. This we think we have attained by transmitting through the sulphureous water a stream of hydrogen gas. In repeated trials made with natural hepatic waters, among them the celebrated Blue Lick water of Kentucky, and with an aqueous solution of hydrosulphuric acid, prepared for the purpose, we have found that by continuing for a sufficient time the washing action of the hydrogen, we could reduce the sulphuretted hydrogen to an almost insensible trace. A volume of 25 cubic inches of the Blue Lick water submitted to this action for one hour retained only a minute fraction of the original charge, and in one and a half hours it gave only the slightest appreciable trace of sulphuretted hydrogen.

The hydrogen used for this purpose, before reaching the vessel which contains the mineral water, is conducted through a solution of potassa in order to remove any hydrosulphuric or carbonic acid it may contain. Thence it is made to pass into a second

vessel containing the sulphureous water through which it bubbles in a brisk but not violent stream. The gas, more or less charged with sulphuretted hydrogen, is led into a third vessel containing either a solution of nitrate of silver to which ammonia has been added, or an alkaline solution of arsenious acid, to arrest the sulphuretted hydrogen. The former solution is greatly to be preferred where the mineral water is only feebly sulphureous. The sulphur thus precipitated is to be determined in the usual way.

Suppose the mineral water to contain free hydrosulphuric acid together with sulphids say of potassium and magnesium, we may proceed as follows:

1. We determine for a given volume of the water the total amount of sulphur present by the use of chlorid of copper or nitrate of silver.

2. We subject an equal volume of the water to the hydrogen current until the escaping gas gives only the faintest trace of hydrosulphuric acid when the jet is received on a surface of white porcelain rendered moist by a mixture of nitrate of silver and ammonia. The mixed gas being passed into the silver or arsenious solution, gives a precipitate from which we determine the amount of free hydrosulphuric acid in the water.

3. We apply heat to the flask containing the sulphureous water which has been thus treated, so as to cause gentle boiling, at the same time supplying the upper space with hydrogen in a moderate but steady stream. It will be found that below the point of ebullition the issuing hydrogen will give scarcely a trace of hydrosulphuric acid, but as soon as the liquid begins to boil, the stream of vapor and hydrogen plainly shows the presence of this substance, then slowly evolved by the decomposition of the sulphid of magnesium or calcium.

4. We treat the remaining liquid with chlorid of copper, or the arsenious solution, to determine the sulphur of the alkaline sulphid which is the only sulphur compound left in the water. The sum of this and the sulphur of the free hydrosulphuric acid subtracted from the total quantity of sulphur gives that of the sulphid of magnesium.

We find that a proportion of hydrosulphuric acid too small to be quantitatively determined by precipitation from the water itself can be ascertained by the use of the stream of hydrogen. It is only necessary to pass the gas which has been transmitted through the water into an ammoniacal solution of nitrate of silver in a long test tube or Liebig's bulb. By continuing the action for one or two hours we obtain a precipitate capable of being separated.

When the water contains no sulphid of magnesium or calcium, it is merely necessary, after determining the total amount of sulphur present, to boil the liquid in an atmosphere of hydrogen

as long as the gas gives a distinct trace of S H by the tache on porcelain as before described; and then by precipitation to determine the quantity of sulphur in the alkaline sulphid of the remaining liquid.

From what has been said it is obvious that the only practical objection to the process here proposed is the tardiness of the displacing action of the hydrogen gas; but considering the acknowledged imperfection of the methods in use, we think that it may be found worthy of adoption.

Second.—On the use of *Carbonic Acid Gas* in the analysis of mineral waters containing Sulphuretted Hydrogen.

As might be inferred from its great absorbability by water, carbonic acid acts much more rapidly than hydrogen in separating hydrosulphuric acid from that liquid. To assure ourselves of this effect, we made several experiments with natural and artificial sulphureous waters, all of which led to the same result. The following example will suffice to show the efficiency and promptness of the displacing action of the carbonic acid.

Twenty-five cubic inches of Blue Lick water contained in a narrow necked bottle, were subjected to the washing action of a brisk stream of carbonic acid gas previously purified by transmission through water. In fifteen minutes the liquid, tested by ammoniacal nitrate of silver, gave a scarcely discernible trace of hydrosulphuric acid, and in twenty minutes not a vestige of it could be detected by the same reagent. The rapidity and completeness of the separation are as striking as the ease with which the experiment can be made.

When therefore a mineral water is known to contain sulphuretted hydrogen only in the free state, we would recommend as the simplest and most exact method for determining this ingredient, to pass through the liquid a stream of washed carbonic acid gas, and to arrest the hydrosulphuric acid, by conducting the current of mixed gas into an ammoniacal solution of nitrate of silver in a small flask or Liebig tube. The precipitated sulphuret being mingled with only a small volume of liquid, admits of more easy separation and determination than when formed in the usual way by adding a precipitant to a large mass of the mineral water. In the case of feebly sulphureous waters this method is we think greatly superior in accuracy as well as promptness to any of those in use. By operating on a considerable volume of the water, the flask or tube will furnish the precipitated sulphuret in sufficient amount for a quantitative determination in cases where in the ordinary way no separable precipitate would be obtained.

As carbonic acid is capable of decomposing the sulphids contained in a mineral water giving rise to free hydrosulphuric acid,

it cannot be employed for determining the quantity of the latter when associated in the water with a sulphid. In this case the stream of carbonic acid would carry with it the hydrosulphuric acid due to its reaction with the sulphids, as well as that existing ready formed in the liquid. For such a water, hydrogen gas used as above explained, is the proper displacing agent.

ART. XXVII.—*On Changes of the Sea-Level effected by existing Physical Causes during stated periods of time;* by ALFRED TYLOR, F.G.S.

(Concluded from page 32.)

PART II.

ALLUSIONS have already been made to the difficulty of proving whether or not the sea-level had been *gradually* elevated, because the rise of the waters would conceal the evidence of their former height except just at the mouths of rivers, where deposits of fluviatile alluvium might raise the land from time to time and keep it above the waves. The recent strata formed at a few such localities have been described by the best observers; and while there are appearances in several cases which might be to some extent explained by the supposition of a gradual rise of the sea-level, yet no proof could be obtained without the concurrent testimony of a much greater number of instances than have yet been brought forward. Sufficient information, it appears, exists to show that the quantity of alluvium in the deltas of such rivers as the Mississippi, Ganges and Po, is so enormous, that the accumulation must have occupied a period of time during which it would not be possible to conceive the sea-level stationary.

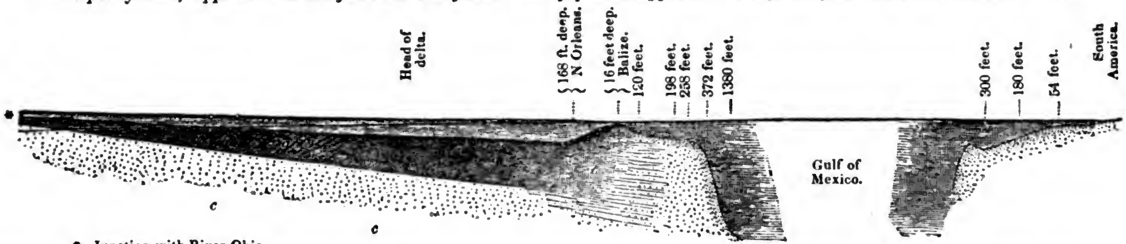
Little progress could be made in an inquiry of this kind without clear views of the operations of rivers. The recent reports of engineers upon this subject supply an important link in the chain of evidence, and enable us to understand the laws which govern the formation of alluvial plains along the lower parts of all river-courses.

The diagram (fig. 8) represents a section of 600 miles of North America, through the alluvial plains and delta of the Mississippi,* together with a section of the Gulf of Mexico, from a point 100 miles east of the Balize to the continent of South America. The sea-bottom is marked from the soundings on the Admiralty Chart, and the depth of the Mississippi and its fluviatile deposit are inserted from statistics collected by Sir C. Lyell.†

* For a most valuable detailed description of the physical geography, &c. of the Mississippi and Ohio valley, see Mr. C. Ellet's paper, Smithsonian Contributions, vol. ii, 1851.

† See note, page 26.

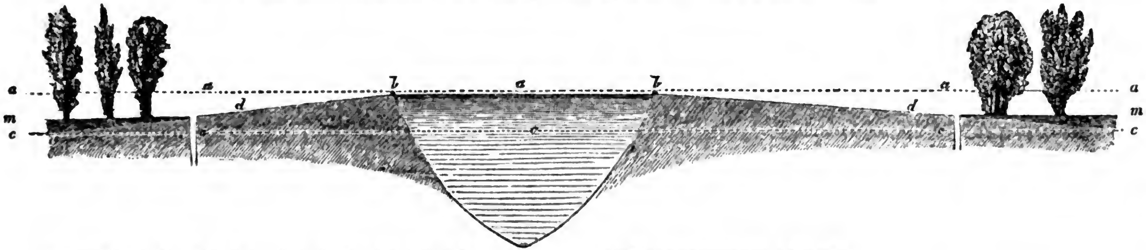
Fig. 8.—*Diagram showing depth of the Delta (supposed, 600 feet); area 14,000 square miles; height of the river above the sea-level 275 feet at *; depth of river, supposed 80 to 200 feet in this diagram; ditto of plains, supposed to average 264 feet; area, 16,000 square miles.*



*. Junction with River Ohio.
a, *a*. Fluviatile strata of the plains of the Mississippi; the slope of these plains is determined by measurement to be about 1 foot in 10,000 towards the sea.
c. Marine strata.

Direct distances:—Junction with Ohio to Balize, 580 miles. Head of Delta to Balize, 180 miles. New Orleans to Balize, 70 miles. [Vertical scale 1 inch to 1000 feet. Horizontal scale 1 inch to 150 miles.]

Fig. 9.—*Transverse section of the Mississippi, where it is 1500 feet wide and 100 feet deep, running in the midst of an alluvial plain 50 miles wide. (This diagram shows the section of slow-flowing rivers in general.)* Vertical scale 100 feet to the inch.



a, *a*. The level of water in the river during flood, which is 25 feet above the level of the distant marshes, *m*, *m*.
c, *c*. The level of water in the dry season.
b, *b*. Artificial banks or levees, 4 feet high.
d, *d*. The banks and plains.
m, *m*. Marshes, supplied with water by filtration from the river at all seasons of the year.

The whole body of water in the river must be in motion, so that even in flood time only a small per-centage of the water and alluvium in the stream can escape over the banks.

It will be seen that the level of the water in the Mississippi, near its junction with the Ohio, nearly 600 miles from the Gulf of Mexico, is 275 feet above that of the sea. The slope of the alluvial plains through which the river winds will therefore be less than 1 foot in 10,000.

The hills bordering the valley of the Mississippi are cut through in several places by the river, thereby exposing good sections of their component strata, consisting of alluvial deposits thought to be much more ancient than those we are about to consider.

An area of 16,000 square miles is occupied by the more modern alluvial formation between the head of the delta and the junction of the Ohio.* It is supposed to be, in the average, 264 feet deep, and is from 30 to 80 miles wide. The true delta extends over 14,000 square miles, occupying a frontage of 2¼ degrees on the coast-line of the Gulf of Mexico, and extends 180 miles inland. At its southern extremity its surface is hardly above the level of high tides, but it rises gradually as it passes inland, and at New Orleans is nearly 10 feet above the sea-level.

A boring near Lake Pontchartain, of 600 feet, failed to penetrate the modern alluvium; and wherever excavations are made, the remains of trees are frequently found, apparently in the places where they grew, but now far below the sea-level. Sir Charles Lyell computes its average depth at 528 feet, and consequently nearly the whole of this modern deposit is below the sea-level, yet is supposed not to contain marine remains. The fall of the Mississippi during a course of 600 miles is shown by fig. 8; the depth of the channel varies from 80 to 200 feet until it approaches the Balize, where it shallows to 16 feet. The rise of the tide at this point is only 2 feet. The depth of the alluvial deposit below the river-channel is also indicated, together with the surface of the more ancient formation upon which the Mississippi has formed this great alluvial deposit, the bottom of which is now more than 500 feet below the present sea-level.

Mr. Charles Ellet, Jun., in a Report to the American Secretary of War, January 29, 1851, communicates the information from which the diagrams figs 1 and 2 are constructed. See p. 23.

The theory of Mr. C. Ellet is, that the velocity of the stratum of fresh water (fig. 1) is communicated entirely to the underlying stratum, composed of salt water, partially to the next stratum 3, but not at all to stratum 4, which is stationary: stratum 5 is also marine, but it flows in an opposite direction to the rest, and restores the salt water which is carried away by the friction of the upper stratum, No. 1, against the suface of No. 2.

It is supposed that the rapid increase of deposit at the bar, fig. 1, arises from stratum No. 5 carrying mud to that point, where its

* Lyell's Second Visit to the United States, 1849, vol. ii, pp. 146–152, 155, 169, 194, 195, 203, 243, &c.

velocity is partially neutralized by impinging against stratum No. 1.

From the following particulars of the deltas of the Ganges and Po, it would appear that they are similarly situated to the Mississippi. "An Artesian well at Fort William near Calcutta, in the year 1835, displayed at a depth of 50 feet a deposit of peat with a red-colored wood similar to that now living. At 120 feet clay and sand with pebbles were met with. At the depth of 350 feet a freshwater tortoise and part of the humerus of a ruminant were found. At 380 feet, clay with lacustrine shells was incumbent upon what appeared to be another dirt-bed or stratum of decayed wood. At 400 feet they reached sand and shingle."*

In the delta of the Po, a well bored 400 feet failed to penetrate the modern alluvial deposit; very near the bottom it pierced beds of peat, similar to those now forming. The coarser particles of mud which have already passed the mouths of rivers may contribute to the marine or fluvio-marine deposits forming outside deltas; but this can only be to a limited extent, as the great bulk of the mud is far too fine to settle near the coast. Little material could be obtained from cliffs along the sea coasts, but we have information of marine currents specially bringing sand and mud from other parts of the sea-bottom to the neighborhood of deltas. (See Mr. Ellet's observations.)

For these reasons, if the further examination of the deltas of the Mississippi and other rivers should lead to the discovery of some recent marine or fluvio-marine strata, it may turn out that such deposits have been more rapidly accumulated than the purely fluviatile beds with which they may be associated. In estimating the age of deltas, allowance, however, ought to be made for such contingences, and also for their organic contents.

Let us now turn to fig. 9, which exhibits Sir Charles Lyell's transverse section of the channel and plains of the Mississippi, and at all points throughout a course of several hundred miles. The dotted lines are introduced to show the variation of the water-level in the wet and dry seasons: *b, b* represent the artificial levée; *d, d* the banks and plains; *m, m* the swamps of the Mississippi. "The banks† are higher than the bottom of the swamps, because, when the river overflows, the coarser part of the sediment is deposited on the banks, where the speed of the current is first checked" (Lyell). The channel, however, is so wide and deep, that even if there were no artificial banks to prevent floods, the river would carry into the Gulf of Mexico the principal mass of the mud it had received with the water of its tributaries; for it is only for a short time in the year that the level of water in

* Lyell. *loc. cit.* p. 248; and Principles, p. 267–270.

† There is a similar section of the Nile and its banks published in the fourth volume of the Quarterly Journal of the Geological Society, p. 344, but communicated by Lieut. Newbold in 1842.

the river is above that of the adjoining plains. The swamps and the numerous lakes formed by deserted river-bends communicate at all times of the year with the main stream. In these places mud could be constantly deposited mingled with the remains of the vegetation which grows luxuriantly in the swamps. The only supply of inorganic matter for raising the level of the vast plains through which the river winds for hundreds of miles, must be the mud deposited upon them during the periodical floods. These are very much prevented by the artificial levée; but when they do occur, their force is augmented by the water being artificially dammed up.

"I have seen, says an eye-witness, when the banks of the Mississippi burst, the water rush through at the rate of ten miles an hour, sucking in flat boats and carrying them over a watery waste into a dense swamp forest" (Lyell). It would appear that the Mississippi differs in size and proportion more than in other respects from our rivers. For instance, when floods occur upon our own alluvial plains, they are most conspicuous at a distance from the stream which caused them, indicating that the parts of the plains nearest the banks are higher than those at a distance from it, and therefore that fig. 9 would also represent the *transverse section of slow rivers generally.* The similarity of the physical features presented by the lower parts of all rivers was particularly remarked by Hutton.*

It has been observed by engineers,† that in all rivers in this country the large quantities of silt brought into them by winter freshets do not tend to choke the channels, but that, at that period of the year, former accumulations of deposit are actually removed by the force of the stream; and therefore, that although winter-freshets bring down silt with them, they carry into the sea a larger quantity than they have introduced into river channels.‡ If it were allowable to assume that the unequal supply of water at different seasons of the year produces effects in the channel of the Mississippi similar to these just described on our own streams, the following consequences might be deduced from the fact that winter freshets remove more detritus than they bring down. The diminution of the speed of the current of rivers assists the deposition of silt upon their beds, as much as its increased speed in the winter season favors its removal. The summer deposit, however thin it may be, cannot occur without contracting the sizes of the channel.

* Theory of the Earth, vol. ii, p. 205-211.

† On this and the following points see First Report of the Tidal Harbors' Commission, above referred to, which contains the opinions of our most celebrated engineers on the phenomena presented by tidal and other rivers.

‡ The author has not met with any explanation of the causes that produces changes in river-channels, although the constant alterations taking place in them have been repeatedly alluded to.

Winter-freshets following a sudden fall of rain would raise the water-level of rivers rapidly, and carry it above the banks before the augmented current has time to scour the river-channel and raise it to its former capacity. Accumulations of silt, small at any one place, must each raise the water a little above its proper level, and the point of overflow will be where the sum of these small elevations amounts to more than the height of the banks, above last year's level. But floods leave a deposit of silt, &c. upon the banks they pass over, which increases the capacity of the channel; and until new deposit has again reduced the area of the stream below its proper size, inundation will not occur.

As each flood raises only the part of the bank it flows over, it is easy to see that the point of overflow will be changed from time to time; and every part of the alluvial plains through which a river flows will be visited in turn by floods, provided there are no artificial banks. These banks assist the scouring power of rivers in winter, because they retain more water in the river; but, on the other hand, silt that would have been carried over the banks is kept within the channel, and this may be the reason why the beds of all navigable rivers have become so much elevated during the historical period. The contraction of water-channels in summer, and their enlargement in winter, is thus directly traced to the unequal supply of rain at different periods of the year.

This being admitted, we have an explanation of the manner in which rivers may, by a succession of floods, build upon alluvial deposits along their courses, at the same time raising their beds in proportion to the height of their plains.

If river-channels were perfectly symmetrical in form, the identical sediment that had fallen in summer might be removed again in winter. It is, however, well known that river-channels are deep on one side and shallow on the other. The principal deposit therefore takes place on the shallow or quiet side, and the principal removal occurs from the deep side where the current runs more quickly.

This may explain why the traveller on the Mississippi sees for hundreds of miles a caving bank on one side, and an advancing sand-bar on the other (Lyell). When the action of the river is also unequal on its two banks in different places along its course, a channel consisting of curves instead of straight lines must be produced. When each curve, however, had assumed the complete horse-shoe form, the water, by travelling round the outer circumference of the bend, will have its effective speed reduced to that on the inner or shallow side. The current would thus become more nearly equal in all parts of the channel, and necessarily the deposit likewise; and in winter it would have a nearly equal tendency to excavate the banks on both sides, which condition of equilibrium might last for some time.

Hutton, in 1795, has remarked, that there is evidence of denudation in every country where at any time of the year the streams carry off any particles of the superficial soil.* The Mississippi must derive its vast supplies of mud from thousands of such tributaries; for it could obtain them from no other source, unless we suppose it abstracts them from its own plains. Certainly in many places soil is being removed from one part or other of its plains; but an equal quantity must be added to some other part, for the river could not make a permanent inroad into its plains without enlarging its channel. This it does not do, or it would be able to carry off the winter-freshets without overflowing, and the present artificial bank would be unnecessary.

I have thus briefly referred to observations made by British engineers which may throw some light on the causes of periodical floods, and changes of channel in rivers, and also upon the formation of alluvial plains along their course. These questions need not further be entered into, because the limited growth of alluvial plains and deltas may be best illustrated by tracing the alteration in the mean level of a large part of North America that would be consequent upon a denudation sufficiently extensive to furnish the alluvium said to exist in the valley of the Mississippi. On the borders of the Gulf of Mexico at the present time marine strata are forming within a short distance of the fluviatile, and frequently alternate with them, because spaces of the sea-shore are enclosed by banks of river-mud and converted into lakes ordinarily communicating with the river, but sometimes with the sea after high tides.

The present marine or fluvio-marine deposits must be composed of mud that has passed the mouth of the river, or washed up by the sea, while the freshwater strata must be entirely formed from sand and mud carried over the river banks, or deposited on the bottom of lakes supplied by the stream before it enters the Gulf of Mexico. An idea of the amount of denudation that has taken place in the interior of North America might be either obtained from the extent of the marine deposits formed of mud that had passed the mouth of the river, or from that of the purely fluviatile and contemporaneous deposits formed from mud which had never entered the Gulf of Mexico.

But it is also necessary to estimate what proportion of the total quantity of mud brought down by the river is carried completely out to sea, compared to what is left either upon the marine or fluviatile portion of the delta.

Sir Charles Lyell has remarked, that the alluvium now remaining in the valley of the Mississippi can only represent a fragment

* Our clearest streams run muddy in a flood. The great causes, therefore, for the degradation of mountains never stop as long as there is water to run; although, as the heights of mountains diminish, the progress of their diminution may be more and more retarded. *Op. cit.* vol. ii, p. 205.

of what has passed into the Gulf of Mexico; and this can readily be believed when we reflect upon the depth and breadth of the channel, and upon the short period of the year that the stream would throw any large quantity of mud into the plains even if there were no artificial banks. We must also bear in mind that only the coarse mud could settle near the shore, for the finer particles could not deposit except in very deep water. For these reasons, even if the mud carried beyond the mouth of the river is only ten times the quantity left behind on the fluviatile portion of the delta and plains of the Mississippi, this amount of detritus could not be obtained without the mean level of one-fifth part of North America being reduced 100 feet by denudation affected by the action of rain, the atmosphere, and running water.* But Hutton (vol. ii, p. 401) remarks, in 1795, that wherever any stream carried off particles of soil in its waters at any period of the year, it might be said that denudation was taking place in that country; yet he particularly observed that the waste of land was very unequal, being much more rapid in the elevated than in the more level parts of any district. It is therefore possible that, during the reduction of the mean surface-level of the land drained by the Mississippi to the amount of 100 feet, some portions of the area might be lowered many times that amount, while other portions might suffer little, or be positively raised by the superposition of alluvial deposit. We are, however, informed by Sir Charles Lyell, that the Mississippi in one part of its course cuts through ancient fluviatile beds evidently antecedent to those recent deposits we have been considering. This formation is also stated to contain the remains of species of plants and animals now existing; so that evidence is to be obtained in this district of still greater denudations (by these results) than those of which we have spoken, and which would produce changes on the surface of the earth since the introduction of the present fauna and flora of extent enough almost to realize Hutton's vision of mountains wasted away by the action of rain, the atmosphere, and running-water, and carried along river-courses into the ocean. It is not necessary to take an extreme view of this subject to gain the object we have in view, which is to show that, during the time occupied by the formation of the Mississippi delta, the sea-level might be perceptibly raised† by the agency of physical causes now in operation.

The reasons for supposing that a rise of 3 inches in each period of 10,000 years might occur, have been already discussed, and it only remains to state that, at the present rate of denudation, it

* The data for calculating the annual quantity of detritus carried over the river's banks, in relation with that carried down to the sea, are very imperfect. Further information on this subject is much needed.

† This change of level may amount, under certain circumstances, to a great extent, but at the *lowest* calculation would be 15 feet.

would require five such periods to produce the quantity of detritus said to exist in the valley of the Mississippi; while it would require fifty such periods to produce the requisite quantity of alluvium on the supposition that only one-tenth of the mud in *transitu* through the river was appropriated for the accumulation of its alluvial plains and delta. Under these circumstances it appears a legitimate conclusion, that the level of the sea cannot be considered permanent for all practical purposes when it may be shown that it might be disturbed by the operation of present causes during the period occupied by the construction of a single geological formation. Elevations and subsidences of the land or sea-bottom would also effect important changes in the height of the sea-level, sometimes counteracting and at others adding to the effects produced by the continuous operation of rivers, &c. The effects produced by these important causes would be an additional reason for not considering the sea-level permanent.

It is hardly necessary to add, that the continual waste of the earth's surface by the carrying of materials into the ocean by rivers and breakers particularly attracted the attention of Hutton. He considered* that this was counteracted by elevatory movements of the sea-bottom from time to time, but particularly mentions that it was not necessary to suppose that the dry land was equally extensive at all periods. Since the fluctuation in the sea-level would be directly consequent upon the destruction of land arising from the operation of rain, the atmosphere, and running water on its surface, such changes would be in harmony with the spirit of the Huttonian theory.

Part III.

The average thickness of the deposit formed on the sea-bottom by the solid materials brought on to it from all sources has been estimated in the preceding part of the paper at 3 inches in 10,000 years, producing an elevation of that amount in the sea-level in the same period. Some portion of the oceanic area may be supposed to receive no part of this supply, while other localities nearer the coast-line obtain a great deal more than the average. In the interval between these places, where the rate of deposit is extremely high, and those where it is extremely low, must lie an extensive tract of sea-bottom, where the accumulation of detritus does not much differ from the average rate, which we have supposed to be 3 inches in 10,000 years. Such localities may be more extensive near those parts of the ocean-bottom which receive no supplies of detritus whatever, but they must stretch up to the coast-line in many places. For instance, if it is supposed

* These remarks of Hutton are here introduced because he takes an entirely different view of this subject to that promulgated by Sir Charles Lyell, who considers that there has been always an excess of subsidence. (See Principles, 1850, p. 543.)

that a supply of 10 cubic feet of sand or mud is obtained from each foot of frontage of any coast-line, and distributed between high-water mark and 20 miles distant, it might raise the mean level of that portion of sea-bottom 1 foot in 10,000 years.

Rivers opening on to the shore might also bring down a still greater quantity of material; but although tides and currents are at work removing the sea-bed in one place and forming sedimentary strata in others from the old and new materials, there must everywhere be portions of every sea-bottom where the rate of deposit is intermediate between the highest and lowest, and may often not differ much from that of 3 inches in 10,000 years. These portions of the great oceanic area, wherever they may be situated, are particularly interesting, because on them the accumulation of sedimentary deposit is taking place without any change in the depth of water, and yet without necessitating the supposition of gradual subsidence of the sea-bottom.* Even where deposits are taking place much faster than the mean rate, the variation in the depth of water would be proportionately less than if the sea-level had been permanent.

The limited supply of detritus derived from cliffs, and the wide distribution of that from rivers, renders it difficult to imagine any very extensive tract of sea-bottom where the rate of deposit derived exclusively from new materials should many times exceed the average. Even on areas where extreme cases of denudation and deposition occurred (in periods when the sea-bottom was unaffected by movements, subsidence and elevation), there would be many parts where the condition of depth would remain unaltered, because on them the rise in the sea-level would compensate the addition to the sea-bottom. Also if, in periods that are past, the supplies of detritus from rivers and cliffs were many times greater than at present, they must have caused proportionately greater fluctuation of the sea-level, and therefore under such circumstances there would also be parts of the oceanic area receiving deposit at the same rate that the sea was rising. There would thus have been opportunities for the accumulation of sedimentary rocks without any change taking place in the depth of the water they were formed in, during the intervals when the sea-bottom was undisturbed by subsidences and elevations. For these reasons, in examining the section of a marine formation containing throughout the remains of the same species of Mollusca, it would require independent evidence to determine whether the equal depth of water indicated by the organic remains had been preserved during the formation of the deposit by means of

* The effect of these causes on the general depth of the ocean would be of little importance in a geological point of view, except for *an extended period of time,* such as must have elapsed during the construction of a great serial group of strata.

changes of the level of the sea-bottom, or that of the sea itself, or of both conjointly.

Great caution must also be requisite in judging of the time occupied in the formation of the older rocks from their mineral character, as the following description of passing events will also apply to periods that are long gone by.

Mr. Austen relates in one of his papers, that "with a continued gale from the west large areas of the dredging-grounds on the French coast became at times completely covered up by beds of fine marly sand, such as occurs in the offing, and which becomes so hard that the dredge and sounding-lead make no impression upon it: with the return of the sea to its usual condition, a few tides suffice to remove these accumulations."*

Mr. Deane, the submarine surveyor, also reported to the Institution of Civil Engineers, that the turn of the tide is felt as soon near the sea-bottom at a depth of 120 feet as it is at the surface; and he represents that the loose materials covering the Shambles Rocks are moved backwards and forwards with every tide.

With these facts before us, what criterion can there be (even by estimating the sources of the detritus) for arriving at the minimum or maximum rate at which sands and marls become permanent additions to the sea-bed? For the materials may present all the appearances of hasty accumulation, and yet the interval of time between the deposit of two strata of sand now contiguous may have been occupied by countless temporary deposits, as quickly brought and as quickly removed by the tide, and leaving no trace whatever of their existence. For the same reasons, we cannot be certain that in the valley of the Mississippi we have an unbroken sequence of fluviatile strata, in which the accumulations of one century form the base for those of the next, from the bottom to the top of the series; because there, as in marine formations, the deposits of one period may have been entirely removed in the next. It is therefore possible that many such movements may have occurred, and that the delta of the Mississippi may have occupied a longer period of time for its formation than could be computed from any data remaining. In the preceding part of the paper the conclusion was arrived at, without taking an extreme view of the rapidity with which the materials may have been collected for its deposition, that the work could not have been completed within a period for which the sea-level could be considered permanent.†

There must be, however, many rivers which are only able to afford very small supplies of mud to any alluvial formations, either

* Quart. Journ. Geol. Soc., vol. vi. p. 79.

† It is hoped that in the course of a few years enough data will be forthcoming to determine more nearly the importance of this variation of level in a geological point of view.

from deriving their water from lakes or from countries with a very small rain-fall. During a period when the gradual elevation of the sea-level was not counteracted by the effects of more powerful causes, there would be conditions near the mouths of some rivers of this kind for the surface of their plains to be gradually elevated by the operation of winter floods at a rate somewhat similar to that of the sea-level. In this manner purely fluviatile deposits might be formed in the neighborhood of the ocean, occupying positions similar to that represented in the lower part of the longitudinal section of the Mississippi, without the necessity of supposing any subsidence of the land. In the upper portions of such rivers, the periodical floods, assisted by the accumulation of terrestrial remains in the adjoining plains, would add stratum after stratum during periods when the surface of the country was unaffected by subterranean movements. It is probable that the rate of deposit might be accelerated in periods of subsidence; but the manner in which rivers form plains along their course in all countries under ordinary conditions, when no subsidence or elevation is occurring, was traced by Hutton.

Even if, in ancient periods, the rate of denudation was greater than at present, and the supplies of detritus to rivers more extensive, the fluctuations of the sea-level and the elevation of the beds and plains of rivers would have been proportionately greater. There would, therefore, still have existed some localities where the rate of the formation of alluvial plains near the sea kept pace with the elevation of the waters; so that, as at the present time, conditions would have existed for the accumulation of fluviatile strata containing terrestrial remains without any subsidence of the land. This is a subject, however, that must be further studied, more especially when its value is considered in relation to the great masses of fluviatile strata either of the Mississippi, the Ganges, the Nile, or the Po. For the above reasons it would be difficult to determine, when examining sections of thick fluviatile strata, whether these accumulations of detrital matter had been formed during subsidence of the land, or during the gradual elevation of the level of rivers and seas, arising from the continual operation of ordinary physical causes.

Art. XXVIII.—*On Fuchs's method for the determination of Iron;* by J. R. Brant.

To determine the amount of iron in any substance, Prof. Fuchs of Munich proposed (Erdmann, xvii, 160) a method which for ease and rapidity of execution is unequalled. It consists simply in boiling the solution of the perchlorid of iron with a strip of bright sheet copper, until the iron is reduced to protochlorid—

the reaction being $Fe_2Cl_3 + 2Cu = 2FeCl + Cu_2Cl$. The quantity of iron is then calculated from the loss of weight of copper, for according to the reaction, as the atomic weight of copper is to that of iron, so is the loss of weight of copper to the quantity of iron sought.

As the idea contained in the method is capable of many analytical applications, it became a matter of interest to determine first the accuracy of the method itself. The iron used in the analyses was fine piano forte wire, and as a preliminary experiment the copper, which was of the purest Lake Superior variety, was boiled for one half hour in concentrated chlorhydric acid, with a loss of 0·69 per cent., and in acid of about one quarter the strength, 0·11 per cent ; showing that the very dilute free acid, in the solution of the perchlorid, can have no sensible effect on the result.

	Iron taken.	Copper dissolved.	Iron found.		
I.	2·0074	2·2010	1·9441 =	96·84	per cent.
II.	2·0591	2·3065	2·0372 =	98·94	"
III.	1·9262	2·1811	1·9265 =	100·01	"
IV.	1·6682	1·8875	1·6671 =	99·93	"
V.	2·2574	2·5045	2·2121 =	97·99	"
VI.	2·0084	2·2855	2·0187 =	100·52	"
VII.	1·9807	2·2015	1·9445 =	98·17	"
VIII.	2·0671	2·3074	2·0380 =	98·59	"
IX.	2·0618	2·3380	2·0651 =	100·16	"
X.	1·0637	1·1907	1·0517 =	98·87	"

The analyses show that although the iron is reduced to protochlorid, the change in color of the solution does not indicate with sufficient sharpness the exact time when such reduction is complete, thus rendering the method inaccurate and unreliable. The method can be made to give accurate results, as soon as some unobjectionable process is given whereby the reduction is rendered manifest independent of mere change in color.

Since the above investigation was completed, a paper on this same subject has been published (Erdmann, lxi, 127) by Dr. Julius Löwe, in which he states that the method, in point of accuracy, leaves nothing to be desired, and gives as proof the following examples:

	I.	II.	III.	IV.	V.	VI.	VII.
Taken,	0·185	0·161	0·126	0·212	0·084	0·282	0·202
Found,	0·179	0·158	0·122	0·212	0·081	0·278	0·201
Difference,	0·006	0·003	0·004	——	0·003	0·004	0·001

Although in these analyses the absolute difference is very small, unfortunately the error in parts per cent. is large; expressed in this manner we have:

	I.	II.	III.	IV.	V.	VI.	VII.
Found,	96·75	98·13	96 82	100 00	96·42	98·58	99·50
Difference,	3·25	1·87	3·18	——	3·58	1·42	0·50

Löwe's own analyses prove then that in point of accuracy the method leaves much to be desired; while by his inconsiderate manner of stating his results he has deceived himself, and probably many others.

New York, June 18th, 1854.

Art. XXIX.—*On Stibiotrizincyle and Stibiobizincyle, two new compounds of Zinc and Antimony, with some remarks on the decomposition of water by the alloys of these metals;* by Josiah P. Cooke, Jr., Cambridge.

During some experiments on Antimoniuretted Hydrogen, made the last winter, I noticed that the alloys of zinc and antimony, which had been used for preparing that gas, continued to evolve gas from pure water, even after they had been washed completely free from the dilute acid employed in the process. This gas proved to be pure hydrogen, and on boiling the washed alloy with water, I found the evolution so rapid as to recommend the reaction as a process of preparing hydrogen in a state of purity. This fact was announced at the last meeting of the American Association for the Advancement of Science; the new process of preparing hydrogen described, and proofs given of the purity of the gas thus obtained.

On investigating this unexpected reaction, I found that not only the alloys of zinc and antimony, but that also pure zinc would decompose boiling water, before they had been acted on by acids. The following table will show the amount of this decomposition. Column headed 1 gives the number of centimetres cubes of hydrogen obtained by boiling 200 grammes of different alloys (granulated) with water. The per cent. of antimony contained in the alloys is given at the left hand side of the table, opposite to the number of centimetres cubes. The composition is known only synthetically. The alloys were made by melting together the zinc and antimony of commerce in the required proportions, making no allowance for impurities. The zinc used was shown by analysis to be almost pure; the antimony was a good article of commercial antimony which contained rather over one per cent. of impurities. The antimony contained in the alloys is therefore to be rated at somewhat less than that given in the table according to the per cent. of antimony which the alloys contain. The two metals having been accurately weighed out, were melted together in clean crucibles and the alloys granulated as nearly as possible under the same conditions. Two hundred

grammes of each alloy were boiled with pure water, the gas collected over water, and the number of centimetres cubes evolved in an observed time read off after the gas had been cooled to 20° C. These amounts were afterwards reduced for ten minutes, and thus reduced are given in the table. As it was impossible to obtain the granules of a uniform size in all the alloys, another set of experiments was made in precisely a similar way except that the alloys were cast into small cylinders of a uniform size. As these cylinders had absolutely the same diameter, and almost the same specific gravity throughout, the same amount of surface was obtained by weighing out 200 grammes of each alloy, and taking care to have the same number of little cylinders in each lot. Column 3 gives the results of these experiments, where of course the same correction for impurities in the antimony must be made in the composition of the alloys. It will be seen that the two sets of numbers compare as closely as could be expected, it being remembered that the amount of surface in the first set of experiments was variable, while that in the second was constant and smaller than the first. These results however must be regarded only as approximations to the truth. The limits of variation in different experiments on the same alloy would quite cover the differences between the first ten numbers of column one, excepting the first, so difficult is it to granulate the alloys to a uniform size, and submit them during the experiments to precisely similar conditions. The numbers of column 3 from which the variations due to difference of surface have been eliminated, are probably relatively to each other very nearly correct.

Table of the Amounts of Hydrogen Gas evolved by 200 *grammes of different alloys of Sb and Zn, in ten minutes, at* 100° *C. measured at about* 20° *C.*

Per Cent. of Sb.	1.	2.	3.
0	2	63	
5	6	34	
10	4	28	3
15	4		
20	6	18	5
25	4	19	
30	4	31	5
35	5	49	
40	6	72	7
45	5	45	
50	8	44	9
55	17	46	
58	130	244	84
60	50	139	47
65	14	35	
70	10	45	7
75	6	36	
80	5	23	6
85	4	20	

A mere glance at the table will discover two facts:

1st. That up to 50 p. c. no great increase in the amount of hydrogen evolved is obtained by increasing the amount of antimony in the alloy.

2nd. That at the alloy containing 58 p. c. of commercial antimony, or about 57 p. c. of pure antimony, there is an immense maximum which is confined between at most two per cent. on either side.

Before passing to the result to which the last of these facts directly points, I will briefly state the few additional facts which I have observed in regard to the decomposition of water by the antimony alloys.

It is a well known fact that the rapidity of the evolution of hydrogen from dilute sulphuric acid and zinc can be very greatly increased by adding to the materials a few drops of a solution of chlorid of platinum. The platinum being immediately deposited on the zinc, forms with it a galvanic pair, and thus increases the affinity of the zinc for oxygen. The same increased action can be produced by the same means in the decomposition of pure water by the antimony alloys. Column 2 of the table gives the results which were obtained by boiling with pure water in a small flask 200 grammes of the granulated alloys, previously treated with the same amount in each case of a solution of chlorid of platinum. After the platinum had been deposited on the granules and the surfaces had been thus blackened, the alloys were thoroughly washed with water and the experiments conducted as in the other two cases. These experiments were made with the same alloys as those from which the numbers of column one were obtained. As however in the experiments with chlorid of platinum new and obvious causes of irregularity were introduced that did not exist in the other two sets of experiments, no great uniformity can be expected on comparing the results. The two main facts however noticed in columns 1 and 3 of the table are quite as prominent in column 2, and also the additional fact that the presence of platinum very greatly increases the rapidity of the evolution of hydrogen from the alloys.

One set of results given in the table requires particular notice; those obtained from pure zinc to be found on the first line opposite 0 p. c. of antimony. It is stated with great confidence by all chemical authors who have written on the subject that Zn does not decompose water at the boiling temperature. On this account the experiments with pure zinc were made with peculiar care and repeated several times, great pains being taken to ensure that both the zinc and water employed were perfectly pure. There is no doubt in regard to the fact of the decomposition which becomes, as is shown in the table, quite rapid when the affinity of the zinc is strengthened by the galvanic action of the platinum.

When the alloys of zinc and antimony are treated with strong acids, hydrochloric or sulphuric, they are as a general rule, and under favorable circumstances, completely deomposed, the zinc uniting with the acid and the greater part of the antimony separating as a black powder, only a very small amount ever, even under the most favorable circumstances, escapes as antimoniuretted hydrogen. When the alloys are in granules it is almost invariably the case with those which contain more than 50 per cent. of antimony that after a short time the acid ceases to act, owing to the formation of a coating of antimony on the surface. The action is of course renewed on reducing the alloy to powder, but here as in other alloys, the less oxydizable metal appears to be able to protect entirely a certain amount of the other from the action of acids.

These facts in connection with those previously stated in regard to the increased action of the alloys on water in presence of platinum sufficiently explain the remarkably rapid decomposition of water obtained by means of alloys which have been previously acted upon by hydrochloric or sulphuric acids, even after the excess of acid and the salts formed have been completely removed by repeated washings. This decomposition is so rapid that I have obtained from 200 grammes of an alloy containing 58 per cent. of antimony prepared as just described and boiled with water, nearly a litre of gas in ten minutes. It is plain that the antimony acts here exactly as the platinum in the previous experiments by forming a galvanic circuit with the alloy. A set of experiments was made with alloys which had been acted upon by acids similar to those the results of which are given in the table. The irregularities however which resulted from the unequal action of the acids on the different alloys, from the differences of surface and from other causes rendered the final results so discordant that they were of no value for comparison. They were always much greater than those obtained by using platinum, with the exception of pure zinc, whose decomposing power was not increased by the action of acids.

This new mode of decomposing water is of value as a process for preparing pure hydrogen, and also for illustrating the composition of water to a class. When the antimony and zinc used are free from arsenic, and the water not in actual ebullition, the hydrogen obtained is chemically pure. If commercial antimony and zinc are used, the gas will be found contaminated with a small amount of arseniuretted hydrogen, so small however as to be with difficulty detected, and entirely inappreciable in the most refined eudiometric experiments.

Gas evolved from an alloy containing 50 per cent. of commercial antimony was burnt in Regnault's eudiometer with the following results:

Tension of hydrogen used, - -	0·379	metres.
Tension of hydrogen + oxygen, -	1·219	"
Tension after combustion, - -	·653	"
Tension of gas consumed, - -	0·566	"

$0·566 \times \frac{2}{3} = 0·378$, amount of hydrogen consumed.

My mode of preparing the alloy for making hydrogen is simply thus: I melt together equal parts of zinc and antimony (this alloy being nearly or quite as active after having been treated with acid as the 58 p. c. of antimony) and granulate as finely as possible. I place the granules in a deep porcelain basin, and pour over them enough hydrochloric acid of ordinary strength to cover them. An energetic action ensues, which I allow to continue until it becomes weak and the acid nearly exhausted. The excess of acid and also the chlorid of zinc formed, I now wash away by allowing a stream of water to pour into the basin until it runs off clear and tasteless. The alloy thus prepared is ready for use. It will evolve hydrogen from boiling water with almost as much rapidity as zinc and dilute sulphuric acid will in the ordinary process, and even after the temperature of the water has fallen to that of the air, the evolution continues though only very slowly. A flask containing about a pound of the prepared alloy covered with water, continued to evolve hydrogen during the last winter for over two months, where the temperature was seldom above 4° C.

The rapidity of the evolution of hydrogen from the alloy and boiling water diminishes quite rapidly and finally after several hours ceases altogether from the formation of a coating of oxyd on the surface. The activity of the alloy can be restored by dissolving off this coating with dilute acids; where however the alloys contain a large per cent. of antimony (above 50) the activity can not be renewed indefinitely in this way since the particles of antimony set free by the acid adhere to the surface of the alloy and soon form a coating impregnable to the strongest acids. For these reasons this process will not be found economical for preparing hydrogen in large quantities, although I think it will be useful where the gas is desired chemically pure.

The large maximum which was observed in the table opposite 58 p. c. of antimony indicated the existence at that point of a definite compound. The true composition of this alloy, considering the impurities of the antimony, was nearly Zinc 43 p. c., Antimony 57 = 100, which corresponds almost precisely to the symbol $Sb\,Zn_3$. The compound which this symbol represents I will term, following the analogy of the nomenclature adopted by the German chemists for similar compounds,

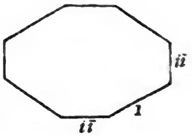
Stibiotrizincyle.

It can be obtained by melting together 58 p. c. of commercial antimony and 42 p. c. of zinc, and allowing the liquid mass when thoroughly melted together, to cool until a crust forms on the surface. On piercing through this crust and turning out the still liquid alloy, the crucible if broken open when cooled will be found filled with the most beautiful prismatic crystals. In order to obtain crystals of any size, it is necessary to use eight or ten pounds of the alloy, and cool the crucible very slowly in sand. These crystals present the following properties. The isolated crystals are small, a few tenths of a line only in diameter and not generally over an inch in length. They tend however to form compound crystals with parallel major axes which are often several inches in length and a quarter of an inch in diameter. Naturally they present a silver white color and a beautiful metallic lustre. The surfaces are often however iridescent, owing to a slight oxydation, and the true color is then only seen on the fracture. Sp. Gr. of crystals = 6·48, Homer.

Their form is that of a rhombic prism, with sometimes only one, but generally with both sets of edges truncated. A section through the lateral axes is given below with the angles between the planes of the prism. The crystals invariably, so far as I have observed, run out to fine points, and although I have examined many hundreds of these crystals, I have never seen one with a termination.

I on $i\bar{i}$ = 148° 30′
I on $i\breve{i}$ = 121° 30′
I on I over $i\bar{i}$ = 117°

1.



I have observed variations from the angles given above on crystals of the same crystallization amounting to ten minutes. The angles given measured the same to a minute on crystals from three different crystallizations, and are therefore regarded as the most probable.

The composition of the crystals obtained as above was found on analysis to correspond very closely to $Sb\,Zn_3$. Of three analyses made by myself of crystals from different crystallizations, obtained by melting together 58 per cent. of commercial antimony and 42 per cent. of zinc, the greatest difference between either the zinc or the antimony found and that required theoretically was five-tenths of a per cent. If we assume that the atomic weight of zinc = 32·53, and that of antimony = 129·03, which accords with the best recent determinations, then the composition of $Sb\,Zn_3$ is as shown in column 1 below. Columns 2, 3, and 4 give the results of the three analyses just mentioned:

	1.	2.	3.	4.
Antimony,	56·94	57·24	56·50	56·93
Zinc,	43·06	42·83	43·06	43·15
	100·00	100·07	99·56	100·08

There can be no doubt therefore that an alloy which contains 57 per cent. of antimony and 43 per cent. of zinc will give crystals which have a composition corresponding to $Sb\,Zn_3$.

It was found however that the same prismatic crystals could be obtained from melted alloys which contained proportionally a much larger amount of zinc, but not from those which contained less. As the amount of zinc in the alloy was increased, the crystals became less and less abundant, until they seemed to fade out when the amount had been increased to about 84 per cent. A series of analyses were made in order to ascertain how far the composition of the melted alloy influenced the composition of the crystals which were formed in it. The results of these analyses are given in the following table. In the left hand column are given the per cents. of zinc in the alloys from which the crystals crystallized. In the right the per cents. of zinc found in these crystals on analysis. With a few exceptions in these analyses the zinc only was determined. The zinc per cents. marked with my name however, are from complete analyses.

Per cent. of zinc in the alloy.	Per cent. of zinc found in crystals.	
42 per cent. - - - -	43·09	*Cooke.*
43 " - - - -	44·14	*Cooke.*
44 " - - - -	44·26	*Eliot.*
46 " - - - -	46·77	*Eliot.*
48 " - - - -	48·66	*Eliot.*
50 " - - - -	46·89	*Cooke.*
52 " - - - -	47·28	*Homer.*

Here as in the former table the composition of the alloys is only known by synthesis, and as commercial antimony was used for making them, the per cent. of zinc in the left hand column is nearly one too low in each case. Considering this it will be seen that the crystals have the same composition as the alloy up to 49 per cent. of zinc, but that after having taken up 6 per cent. excess of zinc, they seem incapable of taking up any more, so that when the per cent. of zinc is further increased in the alloy, it falls off in the crystals, and the alloy of 53 per cent. of zinc gives crystals which contain one per cent. less zinc than those obtained from alloy of 49 per cent. It is unnecessary to say that well defined crystals were always selected for analysis.

Crystals were measured from most of the different alloys of the last table, and were found to have the same form considering the variation already noticed, as the one figured and described. I

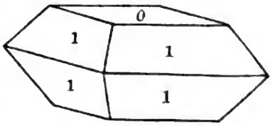
was not however able to obtain crystals from alloys either of 49 p. c. or 53 p. c. of zinc, whose angles could be accurately measured.

This result is certainly very remarkable and important in its theoretical bearings, and will be the more so should it be found that the same variations in composition appear in the compounds. Until I have investigated these I shall refrain from advancing my views on the subject. The facts just stated are substantiated by a very large number of analyses and measurements besides those which appear in this paper.

Stibiobizincyle.

This compound may be easily prepared like the last by crystallizing an alloy containing about 33 per cent. of zinc, and 67 per cent. of antimony. In its natural state like Stibiotrizincyle, it has a silver white color, and a very bright metallic lustre, often however its surfaces display prismatic colors owing to oxydation. It forms in right rhombic octahedrons with basal planes of the Trimetric System. Here as in the other crystals, I have observed variations in the angles amounting to 20 minutes between the extremes. The crystals are frequently very perfect and their faces so plane and bright, that the angles can be measured to a minute. The angles given were all obtained by measurement, except the one over X, which measured six minutes more than that required by the other two. These angles are nearly the mean of those observed.

2.



O on 1 = 122° 15′ measured on each side.

1 on 1 over Z = 115° 30′, measured.

1 on 1 over Y = 118° 24′, measured.

1 on 1 over X = 95° 24′, measured 95° 30′.

Axes $a = 1$, $b = 1{\cdot}042$, $c = 0{\cdot}793$.

These crystals were analyzed by Mr. Eliot with the following results:

	Analysis.		Theoretical $SbZn_2$.
Zinc	= 32·52	Zinc	33·55
Antimony	= 66·86	Antimony	66·45
	99·38		100·00

I have now given an abstract of the results on these two new compounds which I have obtained up to this time. I am now engaged in investigating their chemical relations and compounds. The results of this investigation I hope to be able to publish during the Autumn, in the form of a memoir, to which I must re-

fer for the details and proofs in relation to many points which have been stated in this paper. In concluding, I would express my warmest thanks to Mr. Charles W. Eliot, Tutor in Harvard College, and Mr. Charles S. Homer, assistant in my laboratory, for their assistance and zeal in prosecuting the investigation. Their names have already appeared in the course of the paper.

ART. XXX.—*On the Nature of Forces;* by Lieut. E. B. HUNT, Corps of Engineers, U. S. A.*

IT is a peculiarly significant fact that all the great agencies of Nature which act from local centres or origins through sensible distances, follow the Newtonian law of variation in intensity with an inverse duplicate function of the distance. In this respect, light, radiant heat, sound, gravitation, electric and magnetic repulsions and attractions all agree. As the so-called forces of cohesion, elasticity, chemical affinity, electrolysis, crystallization, capillarity, friction, &c. exhibit sensible actions only at insensible distances, their laws of variation in intensity with varying distances of action are incapable of direct determination. We do not even know if these agencies are original and primary, or resultant and secondary forces. As inertia acts only in the ultimate units of matter, it cannot be supposed to be at all connected with distance. The mutual action of galvanic currents, in which both distance and inclination affect the attraction or repulsion, is clearly a complex result of the transmissive motion of the currents, and forms no static exception to the Newtonian law. It seems therefore a general fact that all primary natural agencies, which act from central origins through sensible distances, are embraced under one mathematical formula, which is that expressed in the all-embracing Newtonian law.

What then is the rational translation or philosophical significance of this law? To this question one answer may be given, which fully illustrates that crowning simplicity so uniformly characterizing natural facts of the highest generality. Newton's law rigorously expresses the necessary facts of simple outward emanation or procession from a central origin. Whatever case of agency emanating from a centre we may suppose, whether it be light, radiant heat, sound, force, or any other, this fact of emanation makes the Newtonian law an inevitable result. This law simply expresses the fact that the agency in question undergoes neither increase nor diminution by outward transmission. If any other than the inverse duplicate ratio be supposed, it must involve

* Read before the American Association for the Advancement of Science, at Washington, May, 1854.

either an increase or diminution of the aggregate agency, as consequent on mere transmission through space. But it is clear that mere transmission is totally incapable in itself of affecting in the slightest degree the quantity of action originally put forth from the centre. Mere change of place cannot, by its very nature, be a producing or destroying cause. The inertia, the structure, the imperfect elasticity of the transmitting medium, may produce a decay of transmitted action, as in the case of light in an imperfect medium or of heat in air; but mere transmission as such, is as wholly powerless to destroy as it is to create action.

The more clearly to perceive that unresisted central emanation necessarily gives the Newtonian law, let us conceive a centre from which action of any kind issues or emanates by rectilinear radiation. Each ray throughout its entire length is the representative of the same quantity of action. Now if we suppose elementary concentric spheres around this origin as a centre, each sphere is pierced by all the rays and hence all the spheres become *loci* of the same amount of total agency in a given time. If the emanation or radiation be supposed uniform in all directions, then the total intensity of action on each unit of surface for any particular sphere, is inversely as its total surface, which is as the square of the distance of transmission. Hence the action on a given surface, or a given constant mass, is inversely as the square of the distance of transmission. Or, instead of rays, we may suppose the emanation to proceed by spherical undulations, where a like train of reasoning will lead to a like result. The two mechanisms of radiation and of spherical undulation concur in giving the Newtonian law, as the necessary expression of unobstructed emanation, the law being indeed but a simple assertion that the emanating agency is neither increased nor diminished by outward propagation or that translation through space, neither makes nor destroys light, heat, force, &c. The same facts in a negative order would characterize a central absorption of agency.

Since free emanation thus leads to the Newtonian law as a necessity, the reverse question arises: whether the existence of the Newtonian law does not of necessity involve emanation? It surely furnishes a powerful evidence of emanation, but is not a positive proof of it; for we can suppose the exact geometrical system of dynamic agency which emanation produces, to be by the original creation and constitution of matter, embodied in an identical static form. For instance, we may suppose an atom so constituted as to fill with its actual and organic self all the space to which its force action would extend, and thus to have everywhere a potentiality identical with that resulting from true emanation. This hypothesis literally makes each atom fill all space, and all atoms actually to coexist in each point of the universe. Thus too, if one atom be moved by its centre, it must every-

where move through every other atom. We are mathematically compelled either to admit this strange universal coexistence of all atoms in each point of space, each atom being everywhere truly distinct, or else to ascribe to an emanation from central points or nuclei, all the forces which follow the Newtonian law. But the exceeding improbability of this coexistence theory may best be estimated by inquiring into the chance of an original static creation being based on the inverse duplicate ratio. *A priori*, this particular ratio has no preeminence of probability over any *sub* or *super* ratio of variation. We may indeed ascribe the existence in Nature of this exact ratio to an intelligent Divine choice or selection, but as a question of chances, it is as infinity to one that some other ratio would have existed.

Between these two conceptions, each of which is a geometrical possibility, this consideration of chances almost compels us to choose the idea of emanation. When too we consider the exceeding complexity of mechanism and the great metaphysical difficulties involved in the idea of coexistence, and when we observe that the inertia of each atom appears thus to be diffused through the entire universe, the coexistence theory seems a hypothesis of the least promising character. For these reasons the existence of Newton's law in any type of force or other agency, seems legitimately and almost by constraint to be referable directly to the emanative outward transmission of the force or agency from its originating central points or nuclei. As all known primary forces do in fact follow this law when acting through sensible distances, the inference follows that all these forces are actually emanative.

But are all primary forces necessarily emanative? Certainly not: yet we ought not, except as a last resort, to hypothecate forces *not* emanative, as such a hypothesis is unwarranted by our actual knowledge. All such hypotheses involve generic force types, unlike that one which includes all forces whose laws are really known to us. Before assuming primary forces, varying inversely with the 1st, 3d or 14th powers of the distance, we are bound to exhaust all the resources for phenomenal interpretation, offered by forces following the Newtonian law. To assume that the same primary force is attractive at one distance and repulsive at another is like saying that yes becomes no by a change of latitude. The expedient of leading one primary force through various alternations of attraction and repulsion, as is apparently done in the theory of spheres of force, must to a reasoning mind appear too conveniently Protean and time-serving to be accepted as any thing better than the fig-leaf of our ignorance. We really know of but one type of force, and that one has a law which means emanation; yet speculation has run riot among all possible ratios of force decrease, and the *force entity* has been treated as a

shuttlecock between attraction and repulsion, just as present convenience dictated. We must have a more grand and simple idea of force, ere the labyrinth of molecular mechanics will yield its clue. In molecular studies, there is a strong and widespread tendency to complex hypotheses which but ill accord with the fundamental simplicity of Nature, and which by hiding our ignorance, effectively retard our progress towards knowledge. To exorcise this tendency would greatly promote the consistent extension of strict mechanical investigation over the rich fields of molecular constitution.

With a view to developing the principles now presented and as a preliminary to some discussion of the theoretical views advanced by Boscovich and Faraday, I will here proceed to develop a few of the properties of central forces varying with an inverse function of the distance, and which may be either emanative or static by coexistence.

Assume a centre of force (or other agency) at an origin of rectangular coördinates, and conceive the force to be radiated uniformly in all directions, each ray being in its entire length the representative of a constant intensity of action, or of an agency varying in intensity with any inverse function of the distance. This mechanism must it is evident, give results identical with those which would result from a corresponding spherical wave mechanism. Suppose now a circular disc to advance or recede relative to the origin, by being moved along the axis of X by its centre and being maintained perpendicular to it; the reception of rays by this disc will be a measure of effect so long as the obliquity of these rays can be disregarded. Calling the force or aggregate action y, when the disc is at the distance x from the origin, and y' when it is at the distance unity; we have $y' : y :: x^2 : 1$, or $y=\frac{y'}{x^2}$. If now we conceive each ray as having an intensity varying with a simple inverse function of x, we shall obtain $y=\frac{y'}{x^n}$, in which n exceeds by two the exponent of variation along each ray.

If we differentiate the equation $y=\frac{y'}{x^2}$, regarding y as a function of x, we obtain $dy=\frac{-2y'dx}{x^3}$, and this is the force decrement corresponding to the Newtonian law. This can best be appreciated by deriving it directly. Let the disc advance towards the origin through a distance $=dx$; the increase of ray reception by the disc, or the differential of the force is found by determining the elementary ring projected around the former position of the disc. Calling the disc radius r, and the width of the added ring dr, we shall have by proportionality $x : -dx :: r : dr$,

and $dr=\frac{-rdx}{x}$, also $y:dy::\pi r^2:\pi(r+dr)^2-\pi r^2$. Hence by reduction and by neglecting dr^2 as an infinitely small quantity of the second order, we obtain $dy=\frac{-2ydr}{r}=\frac{-2ydx}{x}=\frac{-2y'dx}{x^3}$, which is the expresssion above found as the differential of a Newtonian force. The signs of dx, dy and dr depend on the direction of the motion of the receptive surface.

It will be seen by inspecting the above, that not only is Newton's law derived from this consideration of ray-reception, but that the differential equation of that law expresses simply the relation between the differential of distance and that of ray reception. This law also involves the two assumptions which for all appreciable distances are entirely admissible, though not at all so for extremely small distances: first, that the effect of ray obliquity for the same receiving disc may be neglected, and second, that the diffusion over the disc may be regarded as uniform. By substituting spherical atoms for the disc, we at once obtain the case of nature, when the question is of actions between sensible masses.

If we construct the curve of the equation $y=\frac{y'}{x^2}$, we find that both axes of coördinates are asymptotes to its branches or that the force ordinate is infinite at the origin and zero at an infinite distance. But the most remarkable fact in this class of curves is that each particular radius of receiving disc corresponds to a particular curve. When the distance abscissa equals the disc radius, the differentials of force and distance are always equal in construction. The law of the increment is only satisfied by that curve which cuts the line through the origin making an angle of 45° with the two axes, in the point whose ordinate equals the radius of disc. Thus the radius of the receptive disc or atom determines the particular characteristic curve of relation between force and distance: a curve which is the same for a homogeneous sphere of atoms as for a single component atom.

Passing to the more general function $y=\frac{y'}{x^n}$, and differentiating, we obtain $dy=\frac{-ny'dx}{x^{n+1}}$, in which if we substitute y for $\frac{y'}{x^n}$, we obtain $dy=-ndx\frac{y}{x}$. If we suppose now that all the curves corresponding to any particular value of n are duly constructed, and if a right line through the origin make the angle x with the axis of x then $\frac{y}{x}=$ tang. $\alpha=$ a constant; or in $dy=-ndx\frac{y}{x}$, we

find a constant of force increment, for all the points in which a straight line from the origin cuts the various curves of the system. The significance of this result is obvious when we consider that radiation gives shape to the formula. By farther discussion, it would be seen that the increment for a given ordinate varies inversely with the abscissas and directly with the ordinate for a given abscissa.

If the series of parallel curves corresponding to $y=\frac{y'}{x^2}$ be constructed for all values of y' from *plus* infinity to *minus* infinity any possible attraction or repulsion curve for which the force varies as $\frac{1}{x^2}$ will coincide with some one of this series. No two curves of this series when referred to the same origin and axes can be made to intersect. This property is general for all central force curves, in which y varies as $\frac{1}{x^n}$ taken in sets for each value of n from zero to *plus* infinity. This signifies that if any number of central forces acting from the same centre according to the same law are in equilibrio at one point, they must be so at all distances. Also if any number of attractions and repulsions act from one point as $\frac{1}{x^n}$, their resultant also acts as $\frac{1}{x^n}$. Thus

$$y_{a'}+y_{a''}+y_{a'''}+\text{ \&c. }-y_{r'}-y_{r''}-y_{r'''}-\text{ \&c. }=ya\text{ or }yr=$$
$$\frac{y'_{a'}+y'_{a''}+y'_{a'''}+\text{ \&c. }-y'_{r'}-y'_{r''}-y'_{r'''}-\text{ \&c.}}{x^n}=\frac{y'a\text{ or }y'r}{x^n}$$

which is of the original form. Hence all forces emanating from a centre and varying as $\frac{1}{x^2}$ are equivalent to a single resultant varying as $\frac{1}{x^2}$ which is wholly attractive or wholly repulsive: and the same for each value of n. Hence a medium composed of one species of atoms endowed with forces varying according to Newton's law must be unalterably compacted or unalterably elastic. Therefore a single type of atoms with Newtonian forces cannot represent the facts of nature, and we must either suppose other forces than those varying as $\frac{1}{x^2}$ or we must suppose more than one kind of matter.

If we suppose an atom to exercise two central forces, one attractive and one repulsive for which n has different values, their curves will intersect or the forces will balance at one and only one distance. Thus if the ordinary attraction, $y_a=\frac{y'_a}{x^2}$ and any

repulsion $y_r = \frac{y'_r}{x^n}$, act from the same centre their resultant, $y_a - y_r = \frac{y'_a x^{n-2} - y'_r}{x^n}$, can only be zero when $x =$ infinity, or when $x = \sqrt[n-2]{\frac{y'_r}{y'_a}}$. In general $x = \sqrt[n'-n'']{\frac{y'_r}{y'_a}}$, is the abscissa or radius of the point or sphere of equilibrium of these two forces. Hence such a primary attraction and a primary repulsion acting between simple atoms, can together give but one type or form of equilibrium, and thus must fail to give the solid, liquid and gaseous conditions of aggregations. Besides two forces involving different laws of action or values of n, can in no wise give the simple Newtonian form as it appears in gravitation. From this we can say with confidence that heat or the interatomic repulsive force is no mere radial repulsion varying as $\frac{1}{x^n}$.

To suppose three or more distinct atomic forces varying as $\frac{1}{x^{n'}}$, $\frac{1}{x^{n''}}$ and $\frac{1}{x^{n'''}}$, or to suppose a single force following no simple functional law, but being now repulsive, now attractive, now infinite and again Newtonian, is to give ourselves up to bewilderment and to achieve a chaos of explanation. Simple emanation and its resulting law bear *a priori* credentials of being the great facts of dynamic nature, and until they are shown to fail entirely in the exposition of molecular mechanics, a resort to other conceptions must be considered illogical and unhopeful. The hypothesis of two distinct species or kinds of matter, with original forces peculiar to each, but all following the Newtonian law, is far more promising than any other, and Mossotti has to some extent shown its ample power of explanation. One important element is overlooked in his analysis, nor has he developed the mechanical effects of heat on aggregation, though in this respect his views are a vast advance on the total neglect of heat by Boscovich's theory—as also on the expositions by Poisson.

From the point which this discussion has now reached, I wish to examine somewhat the theory of Boscovich and the speculation of Faraday, freely stating some objections not hitherto urged.

Boscovich by denying size to atoms, prevents them from presenting any material surface or volume on which to receive force action. If forces emanate from the atoms of a mass A, and penetrate the volume of a mass B, the atoms of the mass B would not according to the Boscovich theory, present any surface or volume whatever on which to receive the force action. How then is the Newtonian law, or indeed any action to be derived? As this law but expresses the condition of ray-reception, what

does it mean when this reception is precluded by the total lack of magnitude in atoms? Nothing remains but to conceive the force rays or their equivalents from the atoms in B as every where receiving the action of the intersecting rays from the atoms in A, and referring these actions back to their own centres. Now unless these rays are conceived as possessing magnitude, and as actually filling all space, the result of ray-intersections, depending as it must on the number of intersections, would not be the exact Newtonian law, but one essentially departing from this, by a difference which increases as the rays from each atom are supposed less completely to fill all space. Thus to obtain the Newtonian law, we appear to be driven again to that strange hypothesis of each atom filling all space and all atoms coexisting in each point, and to require still other special conditions; all simply as a consequence of denying size to atomic nuclei. As the power of receptivity must exist either in atoms of finite size or in atoms of infinite size, and as we must either locate inertia in a nucleal atom or in an infinite one; we seem quite justified in preferring emanation from and reception by definite nucleal atoms to the bold hypothesis of a static entity, activity and inertia belonging to infinite coexistent atoms. If we attempt to conceive a material mass, as a wall for instance, according to this coexistence theory, we shall find it signally inadequate to the realization of facts to the mind, which though not a logical objection, is a serious practical drawback. But by conceiving atoms as solid, impenetrable, definite volumes, from which force incessantly emanates, and by which force is incessantly received, the mental difficulties wane away, and matter becomes to the mind a localized reality. However small the atomic volumes be assumed, so long as they have a real and finite size, a receptive capacity and the Newtonian law result at once.

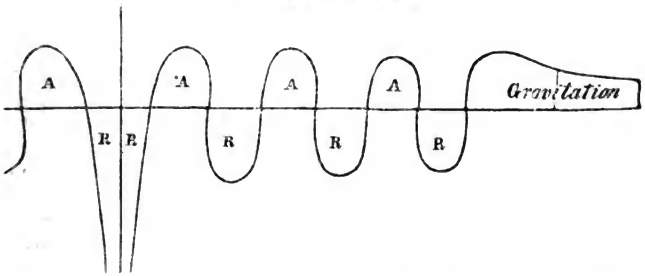
If I rightly apprehend Faraday's views (Phil. Mag., Nos. 157 and 188), they are such as would give a law quite different from Newton's. The interactions of rays conditioned as he supposes, could only give the actual result by so extending the amplitude and number of rays as that all points of space should be points of interaction between the rays of each atom and of all other atoms which is the coexistence theory again. To deduce the actual law from the views so modestly set forth by this excellent investigator, would, I think, be a mathematical impossibility; to say nothing of their inadequacy as they now stand, to serve the cause of molecular mechanics. The objection to the views of Boscovich and Faraday on the ground of their not providing for inertia has been well urged by Airy (Phil. Mag., No. 190).

There is another signal fault of the Boscovich theory, which at this time is peculiarly objectionable. While its mechanism is empirically devised with special reference to the solid, liquid and

gaseous states of aggregation, it really takes no account of heat, but at once refers these states to primary forces assumed for the purpose. Yet it is certainly the degree of heat, and that alone, which in fact mainly determines these forms of material existence. If any relation is supposable between heat and the force spheres of Boscovich, it remains to be discovered what it may be. But as the theory now stands, heat is ignored, and force spheres usurp the work actually performed by heat. This theoretical false causation is a positive stumbling-block in the way to clearer views of heat and molecular aggregation. The more we reflect on the wide range of actions due to heat, the more incompetent to their representation will we find the conception of primary spheres of force. In nature, aggregation is actually almost absolutely ruled by temperature, yet nothing at all like temperature seems legitimately derivable from the Boscovich theory. This theory indeed requires a mass of any given substance when not compressed, always to fill exactly the space given by its atoms being in positions of mutual indifference, and does not provide for expansions and contractions through heat variations.

I will now state a striking proof that the views of Boscovich have received their present somewhat wide acceptance among men of science, without being subjected to that criticism, analysis and comparison with nature, which alone can entitle them to any authority or weight. There is a glaring fundamental oversight involved in his theory as it now stands, and as it is figured in that exponential curve so frequently found in works on this subject, and even in mechanical text-books. This oversight con-

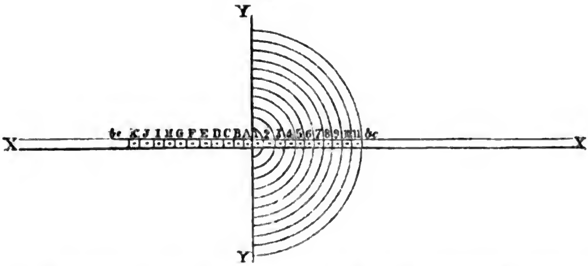
1.—*Curve of Boscovich.*



sists in his not having correctly extended his theory to masses of matter, which, unfortunately for his theory, is the only case occurring in nature. Taking his exponential curve of force between two atoms as it stands, and discussing a mass composed of such atoms, it appears that instead of the various types of aggregation and force manifestation hitherto supposed to result, there will be but a single cohesive type, which will be invariable for each mass.

To illustrate this, let us assume along the axis of X, (fig. 2), a line or thread of atoms, at mutual distances corresponding to a

2.



particular solid or liquid, and acting on each other according to the Boscovich force curve: call the atoms to the left of the origin A, B, C, D, &c., and those to the right, 1, 2, 3, 4, &c. In Vol. I. of Robison's Mechanical Philosophy, there is an exposition of Boscovich's theory, to which most of his disciples are indebted for their acquaintance with his views, and in this, the widest limit of cohesion is fixed at about one-thousandth of an inch, within which are several alternations of attraction and repulsion branches. Now by comparing this distance with the almost infinitely minuter threads, membranes, eye-points, &c. revealed by the microscope in infusorial and other organic forms, or with any of the countless facts showing the extreme divisibility of matter and the differential character of interatomic distances, it will become evident that many thousands of atoms lie within this outer limit of cohesion, or in the one-thousandth of an inch measured in a mass. Boscovich in his Theoria leaves the case essentially in the same condition. Hence the atoms A, B, C, D, &c., on the left of the origin act on 1, 2, 3, 4, &c. on the right of the origin, the attractions and repulsions alternating through many thousands of atoms on each hand. The atom A repels or attracts 1, 2, 3, 4, &c. according to distance, all atoms exterior to the last limit of cohesion being attracted. Thus in the force curve for A, many atoms will be found to correspond to each branch. We may therefore, with almost perfect accuracy regard the areas between the several branches and the axis of X, as proportional respectively to the corresponding aggregate actions of A on 1, 2, 3, 4, &c. The action of B on 1, 2, 3, 4, &c. is analogous, and so of C, D, &c., a portion of the curve towards the origin being cut off for each receding atom. Now on examining the areas between the different branches of the curve as drawn in Boscovich's Theoria, Robison's Mechanical Philosophy, Daubeney's Atomic Theory, Bartlett's Mechanics, &c., it will be seen that the outermost area, corresponding to gravitation, is very much greater than that for

the adjacent repulsion branch, and that the successive attraction and repulsion branches embrace about equal areas. Hence the attraction between A and the gravitating atoms in the line is decidedly greater in its aggregate than the sum of the adjacent repulsions; as is amply realized when we consider that the attraction area extends to infinity between the curve and the asymptote axis. Hence the action of A would be to draw the gravitating part of the column towards itself with a much greater force than it repels the adjacent portion, so that a large surplus of attractive pressure is passed along the column to the next attractive branch, which is thus made greatly to surpass the next repulsion and so on through the whole curve, until the interior repulsion is reached, where the aggregate attractive surplus is balanced by the final indefinite repulsion. The action of B, C, D, &c. is entirely similar, except in the successive pruning of the inner extremity of the curve. Hence the aggregate action of A, B, C, D, &c. on 1, 2, 3, 4, &c. is simply a prevailing attraction which is only effectively resisted by the final indefinite repulsion, and thus the whole mechanism of this curve serves only to make some perturbations in attraction with no palpable result whatever.

Passing now from a line of atoms to a medium or mass of matter, the same result is found only vastly exaggerated. Referring the medium to three rectangular axes of X, Y, Z, and conceiving the line of atoms already discussed as coinciding with the axis of X, we wish to determine the aggregate forces which counteract each other in a superficial unit of the plane Y Z. The total action of the column A, B, C, D, &c. on the matter filling the space beyond the plane Y Z, affords the true criterion of forces acting in a medium, since all the columns parallel to A, B, C, D, &c. can be similarly treated, and thus all forces acting through the plane Y Z will be included in the discussion.

To realize the action of A on the mass beyond the plane Y Z construct with A, as a centre, consecutive spherical surfaces between atoms 1, 2, 3, 4, &c. to infinity. The quantit of matter in these hollow shells increases as the square of the radius hence the aggregate force exerted by and on a shell involves particular function of the square of the distance. The result already found for the action of A on the line of atoms 1, 2, 3, &c., must therefore be multiplied by this function of x^2 to obtain the action of A on the series of spherical shells. For the gravitation branch of the curve the direct and inverse functions of x^2 will neutralize each other, and the curve will straight line parallel to the axis of X, giving an infin gate attraction for an infinite medium. In other words, itating shells give equal total attractions. For the aton C, D, &c. nearly the same result will be found, by a like p s, the only difference being in the cutting off portions from tl i-

gin end of the curve. The total action of A, B, C, D, &c., as of all the parallel atomic columns, will thus be to give this measureless preponderance to the attractions. Hence, a medium composed of atoms acting on each other according to the Boscovich force curve, would be unalterably cohesive, and the effects of the various attraction and repulsion branches interpolated between gravitation and the final repulsion would be totally insignificant. In an indefinite medium, the gravitation area would greatly exceed the area of the final repulsion, so that such a medium would of its own accord rush in upon itself, and become as it were but a single gigantic atom with a definite atmosphere surrounding it.

Whoever will follow this simple exposition of the effects of Boscovich's exponential or experimental curve of interatomic forces, when such atoms constitute a medium or mass, which case alone exists in nature, will see that this curve and the theory it expounds are deplorably false to facts, and destructive to their own pretensions. An exponential curve might doubtless be devised which would provide for the function of the square of the distance, and which would obviate the present gross exaggeration of attraction; though such an empirical curve seems little worth the labor. Surely however it is time for all to discard that misshapen and self-destroying exponential curve which has too long passed unchallenged, because Boscovich was a really great mathematician: great enough indeed, to have fully recognized the faults of his theory had they been actually pointed out to him. It is a strange oversight on his part, that he did not perceive the fallacy involved in his process of first constructing four atoms into a particle, four particles into a particle of the second order, &c.; as if his primary forces would recognize the ideal boundaries of such particles. He in fact neglects all actions except those between adjacent particles, when he passes to a medium, and Robison most pointedly does the same in his favorite conception of springs uniting atoms. If this neglect were really meant, the question would arise as to what becomes of the machinery for gravitation, and what springs are those binding the sun and earth? I cannot but regard the processes of reasoning employed by Boscovich and Robison as singularly rude and gross for such men, and such a subject; nor can molecular mechanics receive a more needful service than by the expurgation of views so abounding in error, and so obstructing the pathway to light. A fabric of objections and difficulties will surely arise in the mind of any well furnished investigator who will really think strictly on this renowned theory of spheres of force. The objections now presented are but specimens.

The speculation of Faraday lacks the definiteness of Boscovich's theory, and is not pushed into the field of molecular aggregation, nor indeed could it be with much hope of success. Ray

vibrations would be a very ingenious mechanism for gravitation, if the Newtonian law could be deduced in a tolerably simple manner from it, but this requisite seems to throw us back on the strange theory of a universal coexistence of all matter. Its inaptness for illustrating molecular mechanics is peculiarly striking if we attempt to imagine ray vibrations for the several phases of molecular constitution. In fact, the reduction of all forces to one law, such as that of Boscovich or Faraday, is like describing all animals as of the color of a chameleon.

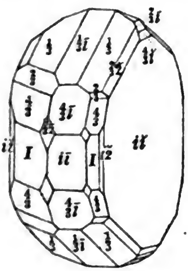
In strange contrast with the Theoria and the Speculation, is the investigation by Mossotti, which is based on real mechanical principles, and which, though quite imperfect, leads to real results. By assigning definite size to atoms, and applying the simple Newtonian law of force to two kinds of matter, conditioned as in the Franklinian electrical theory, modified by Epinus, Mossotti has avoided most of the objections urged against the theory of spheres of force, and has given a glimpse at least of what heat is in the constitution of masses. By extending his investigation, and by supplying some deficient elements, molecular mechanics may at last be established on that simple and sure basis of ordinary mechanical principles, which Newton and Laplace have so distinctly foreshadowed, and which the expanding realms of physical science demand with a positiveness hitherto unknown.

Art. XXXI.—*Contributions to Mineralogy;* by James D. Dana.

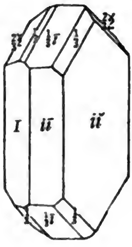
1. *On the relation of Leadhillite in crystallization, to the Anhydrous Sulphates and Carbonates.*

The sulphato-carbonate, Leadhillite, shown to be trimetric in crystallization by Brooke and Miller, has three prominent points of interest: its approximation in form, viewed in one direction, to a regular hexagonal prism—its hemihedrism, which gives it a mono-

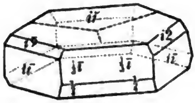
1.



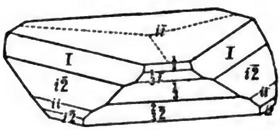
2.



3.



4.



clinic aspect—its twin-composition, under which it takes a rhombohedral character. Figure 1 represents the known planes, taken

from a figure in Mohs's Mineralogy, pl. 13, fig. 97, and rendered nearly holohedral by adding (though of reduced size) the wanting planes. In the occurring crystal, the right-hand *I*, $\frac{4}{3}$, $\frac{8}{3}$, $i\breve{2}$ and $\frac{8}{3}\breve{2}$ are absent. Figure 2 represents an actual crystal of simpler form; it has but one plane *I;* and one plane $\frac{8}{3}\breve{2}$ on either side is obsolete.

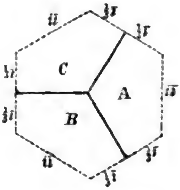
Figures 3 and 4 represent known twin forms, copied with altered lettering from tracings received by the author from R. P. Greg, Jr. The plane $i\bar{i}$ in these figures is made the base.

The prism $\frac{1}{3}\bar{i}$ has for its angle (at top) 120° 40′, which is very near the angle of a regular hexagon; so that these planes with the planes $i\bar{i}$ (fig. 1, 2) make up a hexagonal prism, varying 20 to 40 minutes from the angles of the regular hexagonal prism. And moreover as a consequence, the occurring planes between $i\bar{i}$ and $i\bar{i}$, and between $i\bar{i}$ and $\frac{1}{3}\bar{i}$, are nearly alike in angle—*I* and $\frac{8}{3}\breve{2}$ inclining towards $i\bar{i}$ at the same angle within 8′; and $i\breve{2}$ (not shown in the figures,—situated between *I* and $i\bar{i}$) and $\frac{1}{3}$, at the same angle within 6′. Again, the macrodome $1\bar{i}$, like $\frac{1}{3}\bar{i}$, is near 120° in its angles, giving 119° 40′ and 60° 20′, the acute edge of the dome in this case being above.

Brooke and Miller make the prism lettered $\frac{1}{3}\bar{i}$ the fundamental prism, and $i\bar{i}$ the basal plane. This gives simple expressions for the planes; but it does not appear to exhibit the true relations of the species. We arrive at this conclusion from the following considerations.

The twins consist evidently of *three* united crystals, as so regarded by Brooke and Miller, the plane $i\bar{i}$ (or planes in the series $i\bar{i}$, $i\bar{i}$, $i\bar{i}'$) forming three sides and only three out of the six (fig. 3). If the prism of 120° 40′ ($\frac{1}{3}\bar{i}$ above) be the fundamental prism, and analogous to that of Aragonite, the twins should be formed by composition parallel to the lateral planes of this prism, and moreover two of these lateral planes should be adjacent; or rather the perimeter would include at least four planes of the fundamental rhombic prism. But on the contrary, these planes are *alternate* instead of adjacent, and composition is not parallel to either of them, and hence there is no similarity to any known twin in the Aragonite group. This is seen in the annexed figure (fig. 5);—the sides of the hexagon lettered $\frac{1}{3}i$ are M of Brooke and Miller.

5.



The composition is in fact parallel not to $\frac{1}{3}\bar{i}$ (of figs. 1, 2), that is M of Brooke and Miller, but to $1\bar{i}$ which also is near 120°, having, as stated above, the angle 119° 40′. Hence this form $1\bar{i}$ ($i\breve{3}$ of Brooke and Miller) is better entitled from analogy and general principles, to be considered the fundamental prism of Leadhillite than $\frac{1}{3}\bar{i}$. In fact the prism $1\bar{i}$ (119° 40′) since it is the prism

parallel to which composition takes place, must be the true representative of the fundamental prism of Aragonite and the allied carbonates.

The relations of the sulphates and carbonates have been shown on page 53 of this volume, and had previously been brought out by Hausmann. It is there seen that the unit prism and domes of the sulphates and carbonates are as follows.

Barytes, a sulphate,	($1\bar{i}$) 116° 20′	(I) 78° 20′	($1\breve{i}$) 105° 24′
Anhydrite, "	" 118° 35′	" 77° 4′	" 107° 22′
Aragonite, a carbonate,	(I) 116° 10′	($1\breve{i}$) 81° 40′	($1\bar{i}$) 108° 26′

Adopting the prism of 119° 40′ in Leadhillite, as corresponding to the prism of 116° 10′ in Aragonite, as above shown, the corresponding angles are for

Leadhillite, . . .	119° 40′	76° 44′	107° 26′

For Barytes and Anhydrite (sulphates) the prisms of 78° 20′, 77° 4′ (the supplements of which angles are 101° 40′ and 102° 56′) are ordinarily taken as the vertical prisms; while in Aragonite, that of 116° 10′ is the vertical prism; the difference being one of position. The question now is, therefore, whether the prism of 119° 40′ is the true vertical prism of Leadhillite, and it is thence most closely related to the carbonates, or whether the vertical prism is that of 76° 44′ and 103° 16′, making its closest relation to the sulphates. The latter is the view adopted by the author in a former paper and in the lettering of the above figures, and it appears to be sustained by the following reasons.

1. The planes of the prism of 119° 40′ have not yet been observed, or if observed they are of very rare occurrence. In figure 1, the occurring planes are $\frac{1}{3}\bar{i}$ and $\frac{4}{3}\bar{i}$, without $1\bar{i}$; and in the other zones, we find $\frac{1}{3}$, $\frac{2}{3}$, $\frac{4}{3}$, without the plane 1. Or, putting the crystal on $i\bar{i}$ as its base, according to the view of Brooke and Miller, neither the prism of 119° 40′ is represented, nor any plane in that vertical zone. This is strikingly in contrast with the facts in the prismatic carbonates, in which the fundamental zone is represented by two or more planes in each of the species.

There is therefore a wide divergence from all the carbonates in this respect. And the divergence appears still wider when we consider that the most prominent zone is that of the prism of 120° 40′ ($\frac{4}{3}\bar{i}$ in the lettering of figure 1).

2. The analogies between three trimorphous groups pointed out by the author in the last volume of this Journal, page 210, favor the view that the prism of 103° 16′ is the true vertical prism. As this point is important, the facts are here repeated.

Rhombohedral.	*Trimetric.*	*Monoclinic* (basal cleavage.)
Calcite ($\dot{Ca}\ddot{C}$) 105° 5′	Aragonite, $\dot{Ca}\ddot{C}$, 116° 10′	Barytocalcite ($\dot{Ca}$, $\dot{Ba}$)$\ddot{C}$, 95° 8′
Dreelite ($\dot{Ca}$, $\dot{Ba}$) $\dddot{S}$; 93°–94°	Anglesite $\dot{Pb}\dddot{S}$, 103° 38′ Anhydrite $\dot{Ca}\dddot{S}$, 102° 56′ Barytes $\dot{Ba}\dddot{S}$, 101° 40′	Glauberite ($\dot{Ca}$, $\dot{Na}$) $\dddot{S}$; 83°
Susannite, $\dot{Pb}\dddot{S}+3\dot{Pb}\ddot{C}$ 94°	Leadhillite, $\dot{Pb}\dddot{S}+3\dot{Pb}\ddot{C}$ 103° 16′	Lanarkite, $\dot{Pb}\dddot{S}+\dot{Pb}\ddot{C}$, 85° 48′

The rhombohedral and monoclinic forms, and the trimetric and rhombohedral, have nearly a common difference, 10 to 11 degrees; moreover the sulphates and carbonates in each column differ in angle by nearly a common difference, or 12 to 13 degrees. At the same time, in each, the sulphato-carbonates agree with the sulphates. The fundamental prism of aragonite has its angle 11 degrees larger than the rhombohedral angle of calcite; the prism of anhydrite 9 or 10 degrees larger than the rhombohedral angle of Dreelite; and therefore the prism of Leadhillite is that one which differs by some similar angle from Susannite. The parallelism above is so exact both vertically and horizontally, that the argument must be allowed to have much weight. Its authority becomes irresistible when viewed in a different light.

3. Dreelite is dimorphous with Anglesite and Barytes,—the same compound, essentially, occurring here under a *rhombohedral* and *trimetric* form. Moreover, Dreelite and Susannite are identical nearly in angle, or are homœomorphous; while Susannite and Leadhillite constitute a second case of dimorphism parallel with that just mentioned. Since now this sulphato-carbonate under its rhombohedral form (Susannite) is homœomorphous with the sulphate (Dreelite) and not with the carbonate, hence in its trimetric state (Leadhillite) it should be most closely related to the sulphate (Anglesite or Anhydrite). As the sulphuric acid dominates over the carbonic acid in the Susannite, one form of the sulphato-carbonate, it must also dominate over it in that same sulphato-carbonate under any other form it may present, or in Leadhillite; whence in either case, the forms should be homœomorphous with the corresponding sulphates.

It seems therefore to follow that 103° 16′ is the true vertical prism, as adopted in the figures.

4. We may find further objection to regarding Leadhillite as related most nearly to the prismatic carbonates in the fact that in this case, the most perfect cleavage would be basal, which is not true of any known species of the aragonite group. But after the arguments above stated, we hardly need look further for evidence. An objection to the view adopted might be suggested from the fact that through hemihedrism, one of the prismatic planes *I* is wanting. But there is no reason why hemihedrism should not result in suppressing one of these as well as other planes, and the objection is of little weight. Moreover the fact, which we learn from Brooke and Miller that the plane *I* is also a direction of twin composition, shows that this plane is at least one of prominent or fundamental value in the crystal.

Upon the view which has been discussed, the species *Anglesite*, *Anhydrite* and *Leadhillite* have the following dimensions:

	Prism *I* : *I*	Dome $1\bar{\imath}$	Dome $1\breve{\imath}$	Axes *a* : *b* : *c*
Anglesite	103° 38′	62° 42′	75° 29′	1·6415 : 1 : 1·2715
Anhydrite	102° 56′	61° 25′	72° 38′	1·6836 : 1 : 1·2557
Leadhillite	103° 16′	60° 20′	72° 34′	1·7205 : 1 : 1·2632

We add a remark with regard to the rhombohedral character of the twins.

In the twins, like fig. 4, the series of planes in each sextant are closely related; thus, as has been observed, the planes *I*, $i\bar{2}$, $i\bar{i}$, $i\bar{2}$, respectively have nearly the same inclinations on $i\bar{i}$ as $\frac{2}{3}\breve{2}$, $\frac{1}{3}$, $\frac{1}{3}\bar{i}$, $\frac{1}{3}$ have on the opposite $i\bar{i}$. From *I* the planes narrow downward, and from $\frac{2}{3}\breve{2}$ they narrow upward and so alternating around. In fig. 3, there is a corresponding alternation, though of less extent. Comparing it with the simple crystal, it looks like an inversion of the alternate sectors; but as the compound form contains only three simple crystals, an actual alternate inversion is impossible. As the plane *I* is a fundamental plane, the occurring one (see fig. 2) should have a supremacy in the twin, and with it, the series to which it belongs: and as this series in the simple form diminishes from *I* to the opposite side (the right in fig. 2), this would imply a reverse enlargement of the next or ($\frac{1}{3}$) series, and by this alternation the rhombohedral character would result. The fact, moreover, that the compound is dimorphous and that the other form is rhombohedral, with the same angles nearly as the twin of Leadhillite (as shown by Brooke and Miller) may suggest further reason why the twin should take the alternating or rhombohedral character.

These views are especially interesting as bearing on the subject of dimorphism, and illustrating the passage of a trimetric form to a rhombohedral.

2. *On the so-called Silico-Titanates and Silico-Tantalates.*

In a former number of this Journal it was shown that Sphene was a true silicate of the form $(\ddot{\bar{R}})^3\dddot{Si}^2$, or what is equivalent $(\ddot{\bar{R}})\dddot{Si}^{\frac{2}{3}}$, in which

$$\ddot{\bar{R}}\,(\text{or } R^2O^3) = Ti\,O^2 + Ca\,O.$$

It is consequently *trimorphous with Andalusite and Kyanite.*

In this volume, page 130, the author also observes that the formula of Keilhauite, on the same principle may be

$$(\dot{R}^3, \ddot{\bar{R}})\,\dddot{Si}^{\frac{2}{3}},$$

and that of Wöhlerite

$$(\dot{R}^3, \ddot{\bar{Zr}}, \ddot{\bar{N}}i)\,\dddot{Si}.$$

The special formula of this last afforded by the analyses, is

$$(\tfrac{6}{10}\dot{R}^3 + \tfrac{3}{10}\ddot{\bar{Z}}r + \tfrac{1}{10}\ddot{\bar{N}}i)\,\dddot{Si}, \text{ or } 6\dot{R}^3\,\dddot{Si} + 3\ddot{\bar{Z}}r\,\dddot{Si} + \ddot{\bar{N}}i\,\dddot{Si} = (\dot{R}^3, \ddot{\bar{R}}, \ddot{\bar{R}})\,\dddot{Si}.$$

The analysis by H. Rose of *Tscheffkinite* (Pogg. lxii, 591) appears to lead to the same general formula with that of Keilhauite, or

$$(\dot{R}^3, \ddot{\bar{R}})\,\dddot{Si}^{\frac{2}{3}}.$$

Schorlomite afforded Whitney the formula—

$$\dot{C}a^3\,\dddot{Si} + \ddot{\bar{F}}e\,\dddot{Si} + \dot{C}a\,\ddot{T}i^2$$

Making the $\ddot{T}i$ a base as above, the oxygen ratio for the bases and silica is 6 : 11. But if the silica as obtained be a little too high,

the ratio may be 5½ : 11 or 1 : 2, whence would come the formula

$$2\dot{R}^3\,\dddot{S}i^{\frac{1}{2}} + \bar{R}\,\dddot{S}i^{\frac{1}{2}} \quad \text{or} \quad (\tfrac{2}{5}\dot{R}^3 + \tfrac{3}{5}\bar{R})\,\dddot{S}i^{\frac{1}{2}} \quad = (\dot{R}^3, \bar{R})\,\dddot{S}i^{\frac{1}{2}}$$

(analogous to that of staurotide) = Silica 23·3, titanic acid 22·9, peroxyd of iron 22·4, lime 31·4 = 100. It gives 2 per cent. too little of silica, according to the analyses, while agreeing closely with the results in other respects.

Mosandrite, in a similar manner, gives for the oxygen ratio of the protoxyds, peroxyds and silica 1 : 2 : 3, or of bases and silica 1 : 1 (precisely 16·57 : 15·86); affording the formula

$$\dot{R}^3\,\dddot{S}i + 2\bar{R}\,\dddot{S}i + 4\tfrac{1}{2}\dot{H} \quad \text{or} \quad (\tfrac{1}{3}\dot{R}^3 + \tfrac{2}{3}\bar{R})\,\dddot{S}i + 1\tfrac{1}{2}\dot{H}, = (\dot{R}^3, \bar{R})\,\dddot{S}i + Aq,$$

which, excluding the water, is the formula of epidote. The crystallization of mosandrite has not been clearly made out.

It is probable, that there are no true silico-titanates or silico-tantalates, the titanic or tantalic acid being a base in each case.

3. *Tourmaline.*

The author has shown that the general formula of Tourmaline is

$$(\dot{R}^3, \bar{R}, \bar{B})\,\dddot{S}i^{\frac{3}{4}},$$

the oxygen ratio between the silica and all the other bases being 3 : 4, as ascertained by Rammelsberg, and this being the only constant ratio. The oxygen ratio for the protoxyds, peroxyds, and boracic acid, as deduced from Rammelsberg's analyses, varies greatly. Group I, affords mostly the ratio 4 : 12 : 4,—Group II, the ratio 4 : 15 : 5,—Group III, the ratios 4 : 21 : 6, 4 : 24 : 7, etc. —Group IV, the ratios 4 : 36 : 11, 4 : 40 : 12, etc.—Group V, the ratios 4 : 48 : 13, 4 : 56 : 12, etc.*

For Group I, the special formula is hence

$$\dot{R}^3\,\dddot{S}i^{\frac{3}{4}} + 3\bar{R}\,\dddot{S}i^{\frac{3}{4}} + \bar{B}\,\dddot{S}i^{\frac{3}{4}} \quad = (\tfrac{1}{5}\dot{R}^3 + \tfrac{3}{5}\bar{R} + \tfrac{1}{5}\bar{B})\,\dddot{S}i^{\frac{3}{4}}.$$

For the Red Tourmaline of Elba, in Group V,

$$\dot{R}^3\,\dddot{S}i^{\frac{3}{4}} + 14\bar{R}\,\dddot{S}i^{\frac{3}{4}} + 3\bar{B}\,\dddot{S}i^{\frac{3}{4}} \quad = (\tfrac{1}{18}\dot{R}^3 + \tfrac{14}{18}\bar{R} + \tfrac{3}{18}\bar{B})\,\dddot{S}i^{\frac{3}{4}}.$$

These appear to be the extreme variations in the species Tourmaline, if we exclude the analysis (No. 30) of a somewhat decomposed variety from Rozena. The formulas for the other ratios may be easily written in like manner, in accordance with the general formula above.

Axinite has in like manner the general formula

$$(\dot{R}^3, \bar{R}, \bar{B})\,\dddot{S}i;$$

the analyses afford, as the special formula under this type

$$\dot{R}^3\,\dddot{S}i + 2\bar{R}\,\dddot{S}i + \tfrac{1}{2}\bar{B}\,\dddot{S}i,$$

and this formula was suggested by Rammelsberg in his Handwörterbuch, i, 72.

* The oxygen ratios deduced by Rammelsberg for the protoxyds, peroxyds and silica, *the boracic acid* being included with the silica, are for Group I, 1 : 3 : 5; II, 1 : 4 : 6; III, 1 : 6 : 8; IV, 1 : 9 : 12; V, 1 : 12 : 15.

Art. XXXII.—*Notice of the Life and Writings of the late Dr. Waldo Irving Burnett;* read before the Boston Society of Natural History, July 19th, 1854, in accordance with a vote passed at the previous meeeting. By Jeffries Wyman, M.D.

Mr. President—From time to time Death has entered our circle, and taken from our number one and another of those who have been our most active associates, and to whom we have been bound by the ties of personal regard or of friendship. In nearly every instance they have been removed in full manhood, or even at a later period, when the labors of a life of the ordinary length had been nearly finished. But never before has there been taken from amongst us one who, in his devotion to natural science, has, in so brief a life, left so many memorials of zeal and industry as he, to whose memory we would now pay our tribute of respect.

Waldo Irving Burnett was born in the town of Southboro', Mass., July 12th, 1828. His father (the late Dr. Joel Burnett) was a man of distinguished excellence in his profession, and to the qualities of a good and useful citizen united those of an ardent lover of nature, of whose works he was a close and faithful observer. Botany and Entomology especially received his attention, and without the aid of genial spirits, or the intercourse with kindred minds, were studied with no ordinary zeal during the few leisure moments which were left him after the demands upon his time by a laborious profession had been satisfied. His love of nature was transmitted to the son, and was manifest in early boyhood, when the observation and study of insect life took a strong hold upon his mind. His father experienced a just pride in witnessing these tendencies; but in place of encouragement, which he at first extended with delight, he was soon, though reluctantly, obliged to substitute restraint. His son's mind was too intently absorbed in his pursuits, and fears were excited lest his studies, prolonged into hours stolen from the usual period of repose, should be attended with disastrous results to his physical constitution. His passion, however, grew with his growth and strengthened with his strength, and in the face of all obstacles, through health and through sickness, from an early youth to his early grave, it was never abated.

He had not the advantage of a collegiate education; this he chose to forego, not from any indifference to its value, but from a sensitive unwillingness to subject his father to any unnecessary expenditure of his means. He gave early indications of great mental activity, and mastered with ease all the studies of the Academy; in mathematics, especially, he was unusually proficient, and drew from his teacher the confession that in this de-

partment he was no longer capable of giving him instruction; and it was the habit of other teachers in the neighborhood to send to young Burnett for the solution of difficult questions which they themselves were incompetent to master. Almost without assistance, at a later period, he made himself familiar with the French, Spanish, and German languages, and during the latter part of his life had made some progress in the Swedish.

At the age of sixteen he had become thoughtful beyond his years; and then commenced the development of those tendencies in his mind which ever afterwards were so conspicuous, and which continued to exert a controlling influence, viz.: the desire of gaining an insight into the nature of things, and of forming philosophical ideas and conceptions of natural processes, conceptions and ideas which can be obtained only by the exercise of the higher powers of the mind. Mesmerism, materialism, and theological questions occupied his thoughts, and were frequently written upon and discussed by him. On all of these he manifested independence and continuity of thought, and persistence in whatever direction his mind was turned. It was at this early age that his interest in the study of medicine commenced, when he accompanied his father in his professional visits, and witnessed the effects of disease, as manifested in the examination of bodies after death. Entomology now especially engrossed his thoughts, and nearly all his leisure moments were occupied in collecting, studying and classifying insects. While yet in his sixteenth year his father died. This event materially changed his prospects, and was met with firmness and decision, and in the course of the following year, finding that something must be done for his support, he commenced teaching school, and at the same time gave his attention to the study of medicine.

The subsequent years of his student life were spent under the direction of Dr. Joseph Sargent, of Worcester, with whom there grew up warm mutual personal regard and friendship: in the Tremont Medical School in Boston, which has given to the profession so many zealous and productive laborers in medical science: and in the Massachusetts General Hospital. He was ardent and industrious as a medical student, but never allowed his attention to be withdrawn from the study of nature, the microscope becoming his constant companion, and a source of never-failing pleasure. As evidence of his ability it may be stated that in two successive years he gained the annual prize offered by the Boylston Medical Society. The subject of the first essay was *Cancer*, treating especially of its microscopic structure; and of the second, *The Sexual System, or the production of being, considered as to its physiology and philosophy.*

In 1849, at the age of 21, he graduated in medicine, and soon after visited Europe, where his attention, especially at Paris, was

given almost exclusively to natural history and microscopic observation. The expectations of intellectual progress which he now looked forward to with so much interest, were soon doomed to severe disappointment. It was in Paris that he received the first serious warning that consumption, the disease which eventually destroyed his life, had already marked him for its early victim. After an absence of only four months, he re-embarked for America, to receive the benefit of a more genial climate in one of the southern states, and each successive winter he passed either in Carolina, Georgia or Florida, in order to avoid the inclement and uncongenial climate of New England. He had now no permanent location, was constantly shifting from place to place, to mitigate, as far as possible, the steady progress of his disease. Everything seemed adverse to anything like connected study. Nevertheless, it was during these few unsettled years that he accomplished an almost incredible amount of intellectual labor. He was incessantly occupied with his microscope; his mind was ever on the alert, and he allowed scarce a day to pass without some observation, without something added to his stock of acquired knowledge.

In the winter of 1851 he delivered at the Medical College in Augusta, Ga., a successful course of lectures on Microscopic Anatomy. In the summer of 1852 he prepared the principal work of his life, the Essay which received the prize from the American Medical Association. His two former prizes were competed for only by his fellow students; but the third, it is no small praise to say, was open to the competition of the whole medical profession throughout the country.

While yet a medical student he became an active member of the Boston Society of Natural History, and was soon after elected Curator of Entomology. In 1851 he was elected a member of the American Academy of Arts and Sciences—one of the youngest members ever admitted into that body. His communications to different scientific bodies and journals were very numerous and on a great variety of subjects, and give such evidence of industry and enthusiasm as cannot fail to excite our wonder and admiration. They are too numerous for analysis or even enumeration in this place; but some of the more important ones are found under the following list of subjects, which comprises those of about one-third of the whole number of his memoirs and communications, and which serves to show that his mind was interested in a great variety of questions, and that whenever an opportunity for investigation presented itself, he was always ready with a cheerful heart and patient industry to enter upon his work.*

* His various scientific papers or abstracts of them may be found in the *Proceedings*, also in the *Journal of the Boston Society of Natural History.* In the *Proceedings of the Boston Society for Medical Improvement*, in the *Proceedings* and in

"*On the Hybernation of Insects, and its Relation to their Metamorphosis.*"

"*An account of certain microscopic animals found in a person who died of an enlarged spleen.*"

"*On the external parasites of warm-blooded animals.*" This was a subject to which he had devoted much attention, and in illustration of which he had made large collections of specimens preserved for microscopic study.

"*On the embryology of the Articulata,*" including remarks on the alternation of generations in the Humble bee, (Bombus Americanus,) in which last he ascertained that three generations are produced from one impregnation.

"*On the luminous spots of the great Fire Fly of Cuba.*"

"*Observations on the seventeen-year locust.*"

"*On Spermatozoa.*"

"*On the origin, development and structure of the kidneys throughout the vertebrated division of animals.*"

"*Notes on the Rattle-snake, relating to its dentition, to the physiological effects of its poison, and to alcohol as a remedy.*"

"*Some account of an Insect, (Rhinosia pomatella,* Harris,) *and its recent injuries to the fruit and forest trees of New England.*"

"*On the development of Viviparous Aphides, or plant lice.*" This is a subject of great interest, and it was investigated with great ability. Since the days of Bonnet it has been well known that several successive generations of Aphides are produced after a single impregnation. Dr. Burnett studied the successive generations as they first appear in the body of the parent, as illustrated by the species infesting the hickory. If a fully developed, but wingless Aphis is examined in the spring, it is found to contain an embryo nearly mature; and this embryo contains already the first germs of the third generation, in the form of single cells or a small number of cells enclosed in a sac. While a few germs are thus formed, others are formed by their subdivision from constriction, until the requisite number is obtained. When they have reached the size of about one three-hundredth of an inch, a yellowish mass forms at one extremity of the egg, and then commences the development of the parts of the insect, which eventually enclose the mass just mentioned. It is this last yellowish mass which furnishes the materials for the next generation. All this, it should be remembered, is effected without the aid of any distinct reproductive organs. There is no ovary or oviduct, but the embryos are developed in the cavity of the abdomen, and discharged through a genital opening merely. In view of the fact that the Viviparous aphides are sexless, Dr. Burnett

the *Memoirs of the American Academy of Arts and Sciences*, in the *American Journal of Science*, in the *Boston Medical and Surgical Journal*, and in the *American Journal of Medical Science*.

regards their mode of reproduction as belonging to the gemmiparous type. Viewed in this way, the different broods cannot be looked upon as so many generations; but on the contrary, the whole suite, from the first to the last, that is, till the production of a winged Aphis, constitute but a single generation. This explanation by a species of budding seems far more satisfactory than that which supposes that either cells or nuclei of the first individual are transmitted by successive inclusions to the last. As this latter idea cannot be supposed to be the result of direct observation, and as no proof is adduced that identical cells and nuclei really pass from one generation to the other, the whole stands merely as an ingenious theory, while Dr. Burnett's explanation [and this view is not proposed for the first time by him,] is in accordance with direct observation. But, in accepting his view, we are compelled to admit the hypothesis, that the germinating force imparted to the first ova is transmitted to the successive broods without the aid of spermatozoa.

"*On the microscopic appearances presented in the intestinal discharges and muscular fibres of a patient who died of the epidemic cholera.*"

"*Tissue and its retrograde metamorphosis.*"

"*On the Geology and other points connected with the natural history of Florida.*"

"*Considerations on a change of climate by northern invalids, and on the climate of Aikin, S. C.*"

"*Considerations of some of the relations of climate to tubercular disease.*"

To these should be added his various critical notices of recent scientific publications in Silliman's Journal, which in view of the short time he occupied the position of associate editor, were quite voluminous, and serve to give us a good idea of his powers of analysis and discussion.

There is no one of his productions, which embodies more of the results of his labors, than the prize dissertation, consisting of two hundred closely printed octavo pages, presented to the American Medical Association in the year 1851, and entitled "*The Cell, its physiology, pathology and philosophy, as deduced from original observations; to which is added its history and criticism. 'Natura in minimis maxima est.'*"

To those who are acquainted with modern physiology, it will be seen at once that he had selected a great subject, one which even the most accomplished minds might approach with distrust. The nucleated cell! that minute organic structure which the unaided eye cannot discern, yet constituting the first stage of every living being, the seat of so many of the complex phenomena of animal and organic life, and the agent by which even the mind itself retains its grasp and exerts its influence upon the living

structures with which it is associated. In entering upon so difficult a subject as this, it was not expected, nor is there any reason to suppose that he himself expected, that he should not lay himself open to criticism. The ablest living histologist, Kölliker, in speaking of the subject of the development of tissue, uses the following language: "Not only does histology not possess a single law, but the materials at hand from which such could be deduced are as yet relatively so scanty, that not even any considerable number of general propositions appear well founded." As laws and general propositions were among the especial objects of Dr. Burnett's researches, it will be seen at once that he has entered boldly into a contested field. But it is to follow him in his labors, and not to hold up to criticism his results, that we have at present to do.

His subject is discussed under the following heads:

1st. *Cell-genesis*, under which he treats of the origin of cells, and advocates a peculiar mode of development, which he claims as original with himself, and the result of his own observations.

2d. *Cell physiology*, or healthy function.

3d. *Cell pathology*, or diseased function.

4th. *Cell philosophy*, or 1st, the relations of cells to the teleological view of organization; 2d, the direct agency of cells in the production and manifestation of nervous power, the intellectual processes, &c.

The general results of his studies of cell life and cell genesis are in his own words as follows: "The great outstanding fact which appears before us as the result of these studies is, that there is fundamental unity of organization. This we have seen to consist in elementary particles, which in both animals and plants are formed upon a common plan. It was the opinion of Schwann and Schleiden, who truly originated this view, that this plan consisted in the preëxistence of a solid fundamental body, (the nucleus) around which is formed a membrane ultimately expanding and constituting the cell. It has been one of my objects to show, that this is not of universal application, by an attempt to demonstrate another mode of cell formation, which is that the fundamental idea of a cell is a simple vesicle, and that the nucleated cell is simply one cell containing another within its walls. With Schwann the nucleus is *exogenous* and *germinative*—with me the nucleus is *endogenous* and reproductive.

"The two conclusions of the studies of cell life are then 1st. The existence of an elementary particle, having an invariable unity of expression, *the cell*. 2d. The universality of the application of this particle for the formation of organized parts, *the tissues*."

In studying cells in relation to pathology, he regards this last as an erring physiology, and concludes, that, both as to their gen-

esis and general aspect as cells, those which belong to abnormal cannot be distinguished from those belonging to normal conditions of life. The genetic and general relations of cells in physiology and pathology are therefore the same. Their difference does not relate to structure, but to their destiny. Physiological cells must be considered teleologically, but pathological ones have no ultèrior object.

Each of the different heads of his dissertation he discusses with great ability, and gives ample evidence that he is not only familiar with the scientific labors of others, but that he is perfectly at home in the different departments of investigation which his essay involves. If it be allowable to express an opinion of its merits in general terms, it may be truly said that it gives evidence of wonderful zeal and industry in research, of acute powers of observation, and of great readiness in perceiving general relationships. It is in connection with this latter faculty that he seems the most liable to error. He appears to have partaken something of the spirit of Oken, and to have given way at times to the suggestions of the imagination, instead of subjecting himself to the severe mandates of reason, and the rigid rules of induction. This is naturally the fault of youth, and for which scientific minds, at the present time, with their tendencies to hasty generalization, may be justly said to be in part responsible. But in one who combined industry, a desire for truth, and an almost unlimited patience in observation, it might have been fairly anticipated that, sooner or later, the better and safer qualities of the mind would have eclipsed all others.

While constantly active as an observer, Dr. Burnett found time to engage in another service which occupied some of the latest hours of his life, and the non-completion of which was a source of anxiety to him in his last moments. This was the translation from the German, of the Comparative Anatomy of Siebold and Stannius. All who are familiar with the published volume, will not fail to see in it another proof of his industrious habits as exhibited not in the translation merely, (itself in this case no ordinary labor) but in the numerous additions to science which, scattered far and wide through scientific journals, have been brought together, and in the contributions he himself has made from his own stores of accumulated observations.

The last scientific investigation to which his time was devoted was into the natural history of the *Orange insect*, which is so destructive to the orange trees of Florida. The habits of this insect he had studied during his last winter's residence in Florida, and had prepared a memoir in reference to it for the American Association for the Advancement of Science, but his ill health prevented his attending their recent meeting.

Such is an imperfect sketch of the scientific labors of our late associate. It only remains to consider his life from another point of view, in regard to its moral aspect. Of this I do not feel justified in treating at length, as my relations to him were not sufficiently intimate to speak from personal observation; but from all I can learn from his associates, from his fellow-students and his more intimate friends, he was a kind and affectionate son and brother, one who enjoyed to an unusual degree home and all its associations; he was a man of a truly benevolent heart, into which irreverent thoughts seemed to gain no admission, or from which they certainly obtained no expression. In all of his studies of nature he seems to have had a pervading perception of God in his works, and often in eloquent words gives expression to his feelings, when some new manifestation of divine wisdom was uncovered to his inquiring mind.

Dr. Burnett's zeal and devotion could not fail to awaken a warm interest wherever he went, among those with whom he associated. He became acquainted with the leading naturalists of the country, and obtained from them and others, willing aid and counsel, as well as respect for his great acquirements. To them he always felt warm feelings of gratitude. But there was one, to whom, more than all others, he was especially grateful, a friend and relative, who at an early period, perceived the indications of uncommon promise for the future, and who with kind heart and benevolent purpose aided and encouraged him in all his undertakings.

He had religious faith and religious hope. To a speculative mind like his, it seemed almost a matter of necessity that the momentous questions which the problem of life involved, should sooner or later, have been presented for examination and discussion, and that before any settled convictions could be reached, they should have found him perplexed and in doubt. Doubts and perplexities in his mind did éxist, but eventually they gave way and were replaced by faith and hope, which lightened his burden when, weary and exhausted, he approached the end of life. He had been long accustomed to look upon death and to talk about it as an event that he must meet at an early period. But death, if not imminent, is something that all look forward to calmly and without emotion, and when we speak of it we are not sure that we give utterance to our most solemn feelings and convictions. But there is one moment when, if ever on earth, the heart, if it opens itself, does so without disguise, if it give utterance, does so without reserve; it is that dread moment when death approaches so near that there is no alternative but to look upon earthly life as finished, its account made up, and when all that remains for the mind to dwell upon, is the dissolution of the body and the realization of another life. A few days before he

died our late associate returned after a winter's absence, to the home of his family, his bodily health exhausted, his energies prostrate. At first he entertained the hope that as before, rest and quiet might restore him partially at least to his usual health, and that he might have yet another opportunity of continuing those labors which he so fondly cherished; but his fast declining strength, the anxiety of those around him, the announcement of his physician and his own quick perceptions soon told that life was drawing to a close, and that for him the great moment was near. In all this he was calm and serene, conversed on the approaching separation without faltering, gave utterance to expressions of deep affection to those who were bound to him by the ties of kin, uttered his prayer for forgiveness, and expressed the solemn conviction, which now rose paramount to every other, that if there yet remained much for him to live for, there was yet far more to die for. On Saturday morning, July 1st, a few days before the completion of his twenty-sixth year, he died.

We cannot but sensibly feel, that in his death we have lost an associate of no ordinaty talents; we can point to no other member of our Society, and to not more than one other naturalist in our country, who has given such proofs of zeal and industry, and who, in so short a life, has accomplished so large an amount of scientific labor. Had he been spared to future years, we cannot but feel the assurance that he would have acquired for himself a far higher place and a still more honorable name in the annals of science. Let us cherish his memory and profit by his example.

The Resolutions which follow, prepared at the request of the Society by Prof. Wyman, were unanimously adopted:

Resolved, That the members of the Boston Society of Natural History have learned with deep regret the death of Dr. Waldo Irving Burnett; that, in his decease, we have lost a most active and zealous associate, and science an ardent, disinterested and productive laborer.

Resolved, That to the family of our late associate, we would offer our deep sympathy for their affliction, in the loss which they have sustained by the early death of one, with whose memory is associated so much of honorable devotion and noble self-sacrifice.

On motion of Dr. Abbott, it was voted, that Dr. Wyman be requested to prepare a copy of the Notice and Resolutions for publication in Silliman's Journal.

[It is with deep sorrow that in place of the usual Contribution from Dr. Burnett for this Journal, we have to present to our readers his obituary. One of the most earnest, faithful and profound laborers in science in the country has ceased from his work while

yet in the midst of research and with new truths constantly developing before his scrutinizing eye. During his connection with this Journal, he exhibited a deep interest in the progress of his special departments, gathering from every available source the means of enriching his papers; moreover he brought to bear upon the subjects before him a large amount of original research which enabled him to select the truth from error and pronounce judgment on the observations of the best investigators. Dr. Burnett was among the few in the land who not only knew well the latest results of the studies abroad in his department, but also labored successfully in testing those results, and more than this, contributed directly to the further progress of science.

The just tribute to the memory of our friend and colaborer by Dr. Wyman, renders it unnecessary for us to indulge in further remarks. His death is a grief to his friends; but science has even more cause to mourn.—Eds.]

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the continuity and force of the current of the magneto-electric machine.*—Sinsteden has published an interesting paper on this subject from which we extract those portions which appear of most importance in a practical point of view. The author's experiments were made with special reference to the employment of the magneto-electric machine in telegraphic operations, but it is clear that they are of equal importance for another practical application of the instrument, namely, to the process of electrotyping. When the inductor of a large machine was made to revolve thirty times in a second so that the iron cores approached and receded sixty times from the poles of the magnet, 120 single current impulses were of course produced, separated by as many intervals of about equal length. A single interval lasted therefore about the $\frac{1}{240}$ of a second, and as an experienced telegraphist with the key of Morse's apparatus opens and closes the circuit about twelve times in a second, there are in this case on the average twenty current impulses for every closure of the circuit. This is quite sufficient to work Morse's apparatus even upon very long lines; a preliminary experiment made by the Royal Telegraph Bureau in Berlin shewed that on the line of 74 (German) miles from Berlin to Dantzic, Morse's registers were worked with uniformity and certainty even when registers were placed at many intervening stations. During a long correspondence not a single uncertainty or error occurred while the magneto-electric machine was used, and the needle of a galvanometer at Dantzic gave a deviation several degrees greater than with the zinc-carbon battery usually employed. Other experiments showed that the machine was capable of transmitting signals with perfect regularity and certainty to a distance of 100 German (about 400 English) miles. In order to

demonstrate still further the continuity of the current, the author examined its magnetic and physiological effects. Two electro-magnets introduced into the circuit supported together 750 lbs., and a vibrating hammer apparatus gave regular and very rapid beats but no musical tone. When the intermitting spring of the apparatus was removed, the conductors held in the hands wet with salt water, and the inductors made to revolve three times in a second, strong shocks were felt in the arms which however were not sharp and sudden like those produced when the intermitting spring was used, but rose, swelled, and sank gently, so that they were received like waves and consequently easily borne. When the entire force of the steel magnet was diminished by laying on armatures and the rate of rotation increased till the inductor made thirty revolutions in a second, no shocks were felt, but instead, a very painful lasting contraction, first in the arms and then in the throat. These phenomena are analogous to those which are produced by a battery of 100 or 150 pairs, though of course it is not for an instant to be supposed that the current of the machine is as continuous as that of the battery. The result is the same, as Neeff and Pouillet have shown, when a battery and an interrupting wheel (blitz rad) are employed. From these experiments the author concludes that the current of the magneto-electric machine possesses sufficient continuity and constancy to be used in telegraphing, and that it approximates to the degree of constancy of a galvanic battery of many pairs. With respect to the intensity of the current of the magneto-electric machine and to certain peculiarities which give it in some measure a *specific* character, the author's experiments are particularly interesting. When the uninterrupted current from an inductor with free helices was conducted through a platinum wire ten inches long and one-tenth of a line in thickness, eight inches of the wire were ignited to whiteness: when a platinum wire one millimeter in thickness was employed as the interrupting spring, dense solid white sparks two lines thick and nearly four lines long were produced, in which the point of the platinum wire was ignited and fused. When a steel watch spring was employed in place of the platinum wire, one-fourth of inch of the steel was ignited and burnt off and a piece of the watch-spring a foot long could be fused in less than a minute. In this experiment the steel spring should form the positive and the interrupting wheel the negative pole; in this way the spring burns most brilliantly and the iron wheel is not injured. When the current was conducted through a voltameter having bright platinum plates immersed in dilute sulphuric acid, about three cubic inches of gas were evolved in a minute. After the plates had been used a long time, they had entirely lost their metallic lustre and become dull and dark gray, while upon the bottom of the voltameter a fine black powder had collected. Both the platinum plates and the black powder, possessed in a high degree the property of causing oxygen and hydrogen to unite: the powder proved to be metallic platinum while the microscope showed that the surface of the plates was rough as if eaten into. With two voltameters five cubic inches of gas were obtained per minute; with six voltameters in the circuit, having however plates of different dimensions, 8·8 cubic inches of the mixed gases were produced. In this last experiment it was very remarkable that

no strong polarization of the platinum electrodes of the six voltameters took place, since on uniting them by a delicate galvanometer, the needle shewed only a very feeble secondary current. Polarization of the electrodes in a very remarkable degree was however produced when the magneto-electric current was passed for a short time through decomposing cells in which the electrodes were lead, silver or nickel in dilute sulphuric acid, or zinc in solution of caustic potash. Two cells containing very dilute sulphuric acid and electrodes of pure silver 3 inches long and $1\frac{5}{8}$ inches wide, were introduced into the circuit. After the current had passed, during a few seconds, the silver plates became covered with gas, the positive plates then became blackish gray, the negative plates covered with a delicate gray coating which rapidly passed to velvet black, increased in thickness, and finally dropped from the plates becoming at the instant whitish gray. The same change of color took place every time that the current ceased, the coating again becoming black when the current again began to pass. When the plates had stood a long time without the current passing, both negative and positive plates were covered with a thick yellowish white coating, and the precipitate had the same color. Spread out on paper this precipitate shews the whitest silvery lustre and proves to be finely divided metallic silver. If after the current had passed half a minute the electrodes were removed from the machine and used as a battery, sparks could be obtained, water decomposed and iron and platinum wire one inch long ignited and fused. When this battery was closed by the spiral of the magneto-electric machine—of course at rest—and by the body, severe shocks were received every time the current was broken: brilliant and loud sparks could also be obtained by this arrangement. The polarization of the battery lasts fifteen minutes in tolerably uniform intensity, and the battery gives, when closed only four or five times in a minute and then immediately opened again, during this whole time equally strong sparks and shocks. When a solution of caustic potash is added to the dilute sulphuric acid in which the plates are dipped the result is very different; no secondary current is produced but there is a strong evolution of *ozone.* Plates of lead in dilute sulphuric acid gave as strong and lasting a secondary current as plates of silver. In this case the positive electrode became covered with a dense layer of peroxyd of lead; the negative electrode became blackish gray but no precipitate was deposited upon it; no ozone was evolved during the passage of the current. The addition of a solution of caustic potash to the sulphuric acid produces a strong evolution of gas and of ozone, but in this case also there is no secondary current. Plates of nickel gave a strong and lasting secondary current. Plates of zinc in a solution of caustic potash give off no ozone; the secondary current is like that of the other metals, but the decomposing cell is soon rendered useless by a heavy white precipitate.

[*Note.*—It is to be hoped that the value of the magneto-electric machine in telegraphing operations will receive in this country the attention which is certainly due to it.—W. G.]—*Pogg. Ann.*, xcii, 1, *May*, 1854.

2. *Galvanic reduction of metallic chromium.*—Bunsen has communicated the results of some further investigations in electrolysis and has shown how chromium, manganese, and several other metals may read-

ily be reduced in small quantities from solutions of their chlorids. The author in the first place has found that the *density* of the current exerts a most important influence on the nature of the products of the electrolytic action; by the *density* of the current is understood the intensity divided by the surface at which the electrolysis takes place. The power of the current to overcome chemical affinities increases with this density. If for instance a constant current is passed through a solution of chlorid of chromium in water, it depends on the section of the reducing pole or electrode whether we obtain hydrogen, sesquioxyd of chromium, protoxyd of chromium, or metallic chromium. The relative mass of the constituents of the electrolyte exerts also a not less important influence. As the unit of measure for the density of the current, Bunsen assumes the current having the absolute intensity 1 distributed upon 1 square millimeter. The intensity of the current was measured by a Weber's tangent's-compass, and reduced to absolute measure by the formula $I = \frac{RT}{2\pi} \tan. \varphi$, in which R is the radius of the ring in millimeters, φ the deviation of the needle, and T the horizontal component of the earth's magnetism expressed in Gaussian units. The value of T was determined by the decomposition of water with the help of the electro-chemical equivalent of water. If A represents the quantity of water decomposed in t seconds by the current whose intensity is I, a being the electro-chemical equivalent of water, we have by Faraday's law, $I = \frac{A}{a\,t}$, and this equation combined with the former gives $T = \frac{2\pi A}{a\,t\,R \tan. \varphi}$. For the density of the current whose absolute intensity is I, the electrode having a section O measured in square millimeters, we have $D = \frac{I}{O} = \frac{RT}{2\pi O} \tan. \varphi$. Bunsen determines the quantity of water decomposed by the loss of weight of the flask in which the decomposition takes place; he finds that the formation of peroxyds of hydrogen may be easily and completely avoided by adding only a small quantity of sulphuric acid to the electrolyte, and keeping the decomposing cell during the experiment at a temperature above 60° C. The error which arises from the catalytic recombination of the two gases upon the platinum plates may also be completely avoided by first amalgamating the plates and then igniting them till the mercury is completely expelled. In overcoming powerful affinities the author uses a decomposing cell, one pole of which consists of the inner surface of a carbon crucible filled with chlorhydric acid, placed within a porcelain crucible and kept hot in a water-bath. A small earthenware cell within the carbon crucible serves to contain the fluid to be decomposed. A narrow strip of platinum dips into this fluid and serves as the second battery pole, the current being compressed upon this to a great density. With this apparatus and a solution of the mixed proto- and sesqui-chlorids of chromium, metallic chromium is easily reduced in leaves having a surface of 50 square millimeters. These are very brittle, and where they adhere to the platinum have a bright metallic lustre: in ex-

ternal appearance chromium resembles iron, but resists better the action of moist air, and on heating in the air burns to sesquioxyd of chromium. Chlorhydric and sulphuric acid dissolve it with difficulty, forming protochlorid and sulphate of protoxyd of chromium. Nitric acid, even when boiling, scarcely attacks it: its density corresponds almost precisely to that deduced from the atomic volume of the metals of the magnesia group. In one experiment the reduction of the metal took place when the density of the current was 0·067: when this density is diminished a point is soon reached when no metal is reduced, but when there is an abundant production of a combination of the two oxyds of chromium as an almost black uncrystalline powder. Chlorid of manganese is decomposed like chlorid of chromium; the metallic manganese is obtained in large brittle leaves which oxydize in the air almost as easily as potassium. When an amalgamated platinum wire is employed as the reducing pole of the battery in concentrated boiling solutions of the chlorids of barium, calcium, &c. the density of the current may be increased to 1, and even beyond that. In the solution of chlorid of calcium acidulated with muriatic acid, the wire becomes covered with a gray layer of calcium which contains but little mercury. The reduction of calcium is however difficult; that of barium is much easier, and masses of amalgam weighing 1 gramme are easily obtained. This amalgam is solid, silver white, and very crystalline: heated in a current of hydrogen it leaves a dark porous mass, in the cavities of which silver white metallic surfaces are visible. The fused chlorids of barium, strontium and calcium are not reduced by the galvanic circuit like the chlorid of magnesium. The chlorid of calcium, even when fused, obstinately retains water, and thus the negative pole becomes covered with a non-conducting layer of lime. When melted tin is made to form the negative pole, an alloy containing from 8 to 12 per cent. of calcium is easily obtained. The author proposes to continue these experiments with other compounds than the chlorids.—*Pogg. Ann.*, xci, 619, *April*, 1854.

[*Note.*—The illustrious German chemist does not appear to have been acquainted with the experiments made in this country by Dr. Hare on the reduction of Barium, Strontium and Calcium by the galvanic battery, as these are not alluded to in his memoir. The discovery of the influence of the *density* of the current upon the intensity and character of the electrolytic effects is undoubtedly one of very great importance. It appears reasonable to suppose that this influence is also very powerful in the battery cells themselves, as well as in the decomposing cells. In those batteries in which, like Grove's and Daniell's, two metals and two liquids are employed, and in which a reduction takes place at the surface of the negative metal, it would seem that such dimensions should be given to the surface of the negative metal that the electric density shall be exactly sufficient to produce the particular chemical effect required at that surface, whether reduction of copper or oxydation of hydrogen. The writer would furthermore suggest that the explanation of the remarkable effects of polarization produced by the magneto-electric machine and mentioned in the previous abstract, is to be found in the peculiar *density* of the magneto-electric current, under the circumstances mentioned, and not merely in its discontinuous

character. *It is not improbable that the density of the current required to produce a particular chemical decomposition will serve as an accurate and available measure of the force of chemical affinity under various circumstances of temperature, mass and pressure.*—W. G.]

3. *On the losses of weight which minerals undergo by heat.*—H. St. Claire Deville and Fouqué have communicated to the Academy of Sciences a memoir on this subject containing results which if confirmed will prove of much importance for mineral chemistry. The losses of weight which minerals experience by heat may arise from the presence of water of fluorine and of boron. The authors assert that the temperature at which the water is expelled from a mineral lies far below that at which the fluorine begins to volatilize. They employ therefore two lamps, one fed with a mixture of alcohol and oil of turpentine, the other a blast lamp in which the vapors of oil of turpentine are consumed. The former perfectly expels the water without a trace of fluorine; the latter completely drives off the fluorine. The nature of the loss of weight which a mineral containing fluorine undergoes depends upon its constitution. The authors prepared a basic silicate of soda, and fused it over the large lamp, with a weighed portion of pure fluorid of calcium. In this case the whole of the fluorine was volatilized as fluorid of sodium, while a silicate of lime remained, containing the whole of the silica. A second experiment was made with topaz: this lost over the large lamp 23 per cent. of pure fluorid of silicon. The authors ingeniously showed this by placing the topaz in the centre of a combination of inverted concentric platinum crucibles, the intervening spaces being filled with lime. This system lost no weight on ignition and the lime was found converted into a mixture of silicate of lime and fluorid of calcium, the fluorine and silicon being in the ratio of 3 to 1 in equivalents. A silicate of alumina remained from the topaz which withstood the heat of melting platinum. The authors assume $4Al_2O_3$, $3Si(O, Fl)_3$ as the true formula of topaz, and explain the observed differences between the varieties of this mineral by considering fluorine as replacing oxygen in greater or less quantity. Between those minerals which lose fluorid of silicon and those which retain all their silicon, there is another class composed especially of minerals which contain lithium. Lepidolite gives over the large lamp a very intense red flame which proves that lithia is volatilized, and explains the variations in those analyses in which lithium and fluorine have both been determined after ignition.—*Compt. Rend.*, xxxviii, 317. W. G.

4. *Illustrations of Chemical Homology.*—Under this title Mr. T. Sterry Hunt presented a paper to the American Association at Washington in May last. It was an extension of some of the views already advanced by him in this Journal for March and September, 1853, and discussed many points with regard to the homologies of organic and mineral species. He considers the neutral and basic salts of an acid and base, as members of a homologous series. Thus the three nitrates of lead in the ordinary notation are, PbO, NO_5; $HO, 2PbO, NO_5$; and $HO, 4PbO, NO_5$. Doubling these we may write them, $(Pb_2O_2)N_2O_{10}$; $H_2O_2, (Pb_2O_2)_2 . N_2O_{10}$; and $H_2O_2, (Pb_2O_2)4 . N_2O_{10}$; so that, excluding the water, the common formula of the lead nitrates becomes

$(Pb_2O_2)n\,.\,N_2O_{10}$. These salts vary in solubility and in physical characters, but resemble each other in yielding nitric acid and oxyd of lead, as results of their decomposition, and are completely analogous to the homologous series of Gerhardt, which differ by $n(C_2H_2)$. From the relations between basic and hydrated salts, the same view is to be extended to the latter, and species differing by $n(O_2H_2)$, and by $n(O_2M_2)$, may thus be homologous. The above formulas are intended to involve no hypothesis as to the arrangement of the elements, for in the author's view, each species is an individual, in which the different species that may be obtained by its decomposition, have no actual existence.

He regards those silicates which like eudialyte, sodalite, and pyrosmalite, contain metallic chlorids, as oxychlorids, $=(M_2O_2)n\,.\,M\,Cl$, and nosean, haüyne and lapis-lazuli as basic sulphates $=(M_2O_2)n\,S_2O_6$, while cancrinite, and perhaps some scapolites, are basic carbonates. All other silicates are reducible to the same type as the spinels, $n(M_2O_2)$, the formula of silica being SiO, with an equivalent weight of $7{\cdot}1+8{\cdot}0=15{\cdot}1$. Boracic, titanic, niobic and tantalic acids are reduced to the same formula as silica.

Homœomorphous species have similar equivalent volumes, so that the density in species thus related, enables us to determine their comparative equivalent weights, and to fix their positions in a homologous series. The proportion between the silica and the other oxyds may vary greatly in related species, while the characters of the genus or the order are preserved. This is illustrated in hornblende, diopside, and aluminous pyroxenes like hudsonite, where the oxygen of the bases being represented by 8, that of the silica is respectively equal to 18, 16 and 9.

The triclinic feldspars, of which albite and anorthite may be taken as the representatives, furnish another example; the one is a lime feldspar, $\dot{C}a^3\,\bar{S}i + 3\,\dddot{A}l\,\bar{S}i$, and the other a soda feldspar, $\dot{N}a\,\bar{S}i + \dddot{A}l\,\bar{S}i^3$; multiplying the first by $\frac{8}{3}$, and the second by 4, and expanding, they are reduced to a common formula $M_{64}O_{64}$. Petalite, a lithia feldspar, also enters into the same formula, with a similar equivalent volume, while orthoclase belongs to a homologous genus, which is $M_{60}O_{60}$. The formulas with their equivalent weights, densities, and volumes, are as follows:

		Eq. wt.	Dens.	Eq. vol.
Anorthite . .	$(Si_{32}al_{24}Ca_8)O_{64}$	$=1118{\cdot}4$	$\div\ 2{\cdot}76$	$=405{\cdot}0$
Albite . . .	$(Si_{48}al_{12}Na_4)O_{64}$	$=1054{\cdot}4$	$\div\ 2{\cdot}62$	$=402{\cdot}4$
Petalite . . .	$(Si_{51}al_{10}Li_3)O_{64}$	$=983{\cdot}9$	$\div\ 2{\cdot}45$	$=401{\cdot}5$
Orthoclase . .	$(Si_{45}al_{12}K_3)O_{60}$	$=1026{\cdot}7$	$\div\ 2{\cdot}56$	$=402{\cdot}6$

The above formula of petalite requires silica 78·27, alumina 17·31, lithia 4·42 = 100·00, and that of orthoclase, silica 66·18, alumina 20·02, potash 13·80 = 100·00, which agrees with a large number of analyses, although there are varieties which appear to contain more alkali.

Between anorthite and albite, may be placed vosgite, labradorite, andesine, and oligoclase, whose composition and densities are such that they all enter into the same general formula with them, and have the same equivalent volume. The results of their analysis are by no means constant, and it is probable that many, if not all of them, may

be but variable mixtures of albite and anorthite. Such crystalline mixtures are very common; thus in the alums, aluminium, iron and chromium, potassium and ammonium, may replace one another in indefinite proportions, and the hydrated sulphates of copper and magnesian metals, are obtained in similar mixtures. Heintz has shown by fractional precipitation, that there are mixtures of homologous fatty acids, which cannot be separated by crystallization, and have hitherto been regarded as distinct acids. The author insists that the possibility of such mixtures of related species, should be constantly kept in view in the study of mineral chemistry. The small portions of lime and potash in many albites, and of soda in anorthite, petalite, and orthoclase, are to be ascribed to mixtures of other feldspar species.

The paper concludes with a view of the homologous and homœomorphous relations of the metallic oxyds, titanates, niobates and tantalates, and their affiliations with the silicates.

II. Mineralogy and Geology.

1. *Notice of von Kobell's paper on Series of Isomorphous and Homœomorphous Forms*, published in Schweigger's Jour., vol. lxiv, p. 410; by J. D. Dana.—In this early paper of von Kobell, published in 1832, (but which we had not the privilege of consulting till receiving quite recently a translation from Mr. G. J. Brush, now in Munich,) the subject of the relations of form among minerals of the Dimetric and also of the Hexagonal System is presented in a similar manner as regards the general principle, to that of the writer in the last volume of this Journal. Von Kobell aims to show that in the dimetric and hexagonal systems as in the monometric, there are many species related in form that are unrelated in composition. After some details with reference to certain analogous compounds, as Scheelite and Wulfenite, he enters upon a comparison of dimetric species differing widely in composition, and shows the similarity of form, of Meionite and Wernerite; Copper Pyrites and Braunite; Apophyllite and Anatase: to the group of Copper Pyrites, and Braunite, he afterwards adds Nagyagite, Corneous Lead, Idocrase, Uranite, Mellite; and to Apophyllite and Anatase the species Zircon, Rutile, native Calomel. Thus relations among the dimetric species are brought out, very similar to those presented by the writer in his recent paper.

Von Kobell next takes up the Hexagonal System, and shows the relations between the Corundum group (including, as first shown by Mitscherlich, Specular Iron and Ilmenite) and the Calcite group. The relation of the Calcite and Corundum groups is shown by comparing $\frac{1}{2}$R of Calcite with $-\frac{1}{2}$R of Specular Iron; and the rhombohedron of Copper Mica 68° 41′ is shown to be near -2R of Specular Iron; while again Red Silver Ore is observed to be near Calcite in angle, the arsenical variety giving the angle 107° 40′ to 107° 36′. Von Kobell also further remarks that "other hexagonal species may be brought into similar series, if differences of $1\frac{1}{2}$ degrees be neglected. The series of quartz and corundum are united by beryl with the series of apatite and pyromorphite; magnetic pyrites and chlorite both have pyramids with the basal angle 120°." The fact of a relation in form among

hexagonal species is here exhibited, as in the writer's recent paper already referred to; but the relation is somewhat different in kind, and depends on less simple ratios, as is seen in the method of comparing Calcite and Corundum. The relations between hexagonal and dimetric species is not touched upon.

Von Kobell thence concludes that entirely different compounds may have closely similar or identical forms; and similarity of form is, therefore, not an indication of similar chemical composition. This important conclusion is also supported by a brief mention of some examples of similar import, in the trimetric and monoclinic systems, as that of Borax and Augite; Prehnite, Antimony Glance and Epsomite; Amphibole and Augite.

2. *On the Chloritoid of Bregratten in the Tyrol, and Clinochlore of Markt Leugast in Bayreut;* by Prof. von Kobell, (J. f. pr. Chem., 1854, lxii, 92, from the Gel. Anz. k. k. Bayr. Akad. d. Wissensch.)—The Bregratten *Chloritoid* has a blackish-green color and is associated with quartz. An analysis, made with special precautions, afforded Prof. v. Kobell:

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{H}}$
	26·19	38·30	6·00	21·11	3·30	5·50 = 100·40
Oxygen	13·59	17·90	1·79	4·68	1·32	4·88

from which results he deduces the formula

$$(\dot{\mathrm{Fe}}, \dot{\mathrm{Mg}})^3 \dddot{\overline{\mathrm{Al}}} + 2\dddot{\overline{\mathrm{Al}}}\,\dddot{\mathrm{Si}} + 3\dot{\mathrm{H}} \quad \text{or} \quad \dot{\mathrm{Fe}}\,\dddot{\overline{\mathrm{Al}}} + 2\dddot{\overline{\mathrm{Al}}}\,\dddot{\mathrm{Si}} + \dot{\mathrm{Mg}}^2\,\dot{\mathrm{H}}^3.$$

The *Clinochlore* shows lines of cleavage parallel to a rhombic prism of nearly 120°, and also parallel to the shorter diagonal, and like the clinochlore of Pennsylvania, it is optically biaxial. B.B. fuses on the edges to a pale yellowish mass. In borax dissolves with intumescence, and slowly yields a chrome-green glass. Fuses imperfectly with soda to a yellowish mass. Decomposed perfectly by sulphuric acid, and imperfectly by muriatic. The analysis afforded von Kobell:

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dddot{\overline{\mathrm{Cr}}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{H}}$
	33·49	15·37	2·30	0·55	32·94	4·25	11·50 = 100·40
Oxygen	17·38	7·18	0·69	0·17	13·17	0·94	10·22

giving him the formula

$$3\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}} + 2\dddot{\overline{\mathrm{Al}}}\,\dddot{\mathrm{Si}} + 3\dot{\mathrm{Mg}}\,\dot{\mathrm{H}}^2.$$

This Clinochlore occurs in Serpentine.

3. *On the Alteration of Scapolite;* by G. v. Rath, (Pogg., xc, 288.)—This paper is a continuation of an extended examination of Scapolites by von Rath. The author here gives analyses of different altered Scapolites.

(1.) *Mica* after Scapolite, from Arendal, Norway. The altered crystals are 6 inches in length; they are covered with mica crystals, and consist of an aggregation of scales of the same. G. = 2·833. H. = 2·5.

Analysis—

$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{H}}$	$\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$
44·49,	24·91	4·84	2·14	0·36	6·71	1·11	3·44	11·11=99·11

whence the oxygen ratio for $\dot{\mathrm{R}}$, $\dddot{\overline{\mathrm{R}}}$, $\dddot{\mathrm{Si}}$, 0·38 : 2·12 : 4. The analysis shows an addition of 6·71 of potash, not found in the unaltered Scapolite of Arendal, besides a removal of the larger part of the lime by carbonic acid, and also other changes.

(2.) *Yellow Scapolite* from Bolton, Mass. This is a massive, pale yellowish variety. G.$=$2·787. Analysis gave

$\bar{\mathrm{Si}}$	$\bar{\bar{\mathrm{Al}}}$	$\bar{\bar{\mathrm{Fe}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{H}}$	$\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$
49·99	23·01	1·64	3·35	1·73	7·09	0·35	4·23	7·80 $=$ 99·19

Here also the addition of potash is large, being 7·09 per cent., and the composition is near that of Potash mica.

A *Red Scapolite* of Arendal, is next described. The analysis affords 4·42 of potash and 4·31 of soda. A *black scapolite* from Arendal afforded no alkalies and a large amount of magnesia, showing a removal of soda and an addition of the magnesia. Another from the *same* locality, Arendal, has the constitution of epidote.

[The yellow scapolite of Bolton is very similar in composition to the Algerite of Hunt, and sustains the view of Whitney that Algerite is a result of the alteration of Scapolite. It is a singular fact that Bolton alone has afforded to analysts the oxygen ratios for $\dot{R}$, $\bar{\bar{R}}$, $\bar{\mathrm{Si}}$, as follows:

1 : 2 : 4 1·2 : 2 : 4 1·2 : 2¼ : 4 1 : 2½ : 4 1 : 3 : 6 1 : 2½ : 6 1 : 3·9 : 9

a wide variation of composition for a single locality, but readily explicable when the ease with which scapolite undergoes alteration from atmospheric agencies or infiltrating waters is considered.—J. D. D.]

4. *Report on the Salt and Gypsum of the Preston Salt Valley of the Holston River, Virginia;* by Prof. H. D. Rogers. Boston, 1854.—This is an interesting topographical, geological and economical shetch of the saliferous deposits of southeastern Virginia, embraced in a rich valley of the Apallachians in Washington county. The deposits of salt, salt water, and gypsum occur on the line of an extensive and profound dislocation of the strata parallel to the main mountain ridges and to the trend of the plain which they enclose. The soil of the valley is wet and peaty; and beneath it to an enormous depth, there appears to be no solid rock, but a deposit of clay and earth, imbedding in places, large bodies of rock salt and of gypsum and saturated in its lower portions with highly concentrated brine. The vertical movement or heave of the rocks along the line of the fracture before mentioned is excessively great, inasmuch as the strata on the southeastern side of the fissure belong to the great Auroral magnesian limestone, the lowest of the Appalachian limestones, equivalent to the Cambrian or lowest fossiliferous system of England, while those on the other or northwestern in immediate contact with them are the saliferous and gypsiferous beds of our Appallachian umbral series, the near representatives in age of the European carboniferous limestone, and in original position of horizontal stratification removed by many thousand feet of interposed deposits from the older lower masses, into contact with which they have been forced by the heave along the fracture. The author in connection with Prof. Wm. B. Rogers, has made approximate measurements of the Preston salt valley, from which he infers that this vertical displacement by which the older Auroral strata have been inverted from the southeast upon the umbral beds, amounts to not less than 8000 feet.

Five productive wells are now in use in this valley, bored to the moderate depth of 200 to 300 feet, and four inches diameter. In the case of one well, over 300 feet of rock salt, divided by a little clay, were passed through without tapping any brine at all. The brine rises in the

well to within 45 feet of the surface, from which depth it is lifted by pumps and distributed to the evaporating houses by wooden logs. The quantity of pure salt now produced is 300,000 bushels per annum, worth about 50 cents. This is the present demand; vastly larger quantities can be supplied when there is a market. It appears from the statements of Prof. Rogers that the brine of these salt wells is stronger and purer than any other brine known in the United States. The usual proportion of salt in it is about 23 per cent.; eighteen gallons yielding one bushel of salt. It is entirely free from the chlorids of calcium and magnesium, and as a consequence of this, and of the absence of iron, the salt is dry and colorless—no appreciable quantity of *bittern* being produced in the evaporation. Gypsum is the only foreign ingredient present in any notable quantity, and this is easily and completely separated in the process of evaporation.

Prof. Rogers estimates the quantity of merchantable gypsum fit for agricultural and other uses, and within 60 feet of the surface, as determined by numerous borings, to be not less than 500,000 tons. It occurs, as this mineral usually does, in detached masses, often of considerable extent, but forming no part of the regular bedding of the adjacent rocks. Three beds of *anhydrite* have been developed on the Preston estate, confirming the view that volcanic steam and thermal waters have been concerned in the production of the gypsum beds. In view of all the facts relative to the actual mode of occurrence of the deposits of gypsum and anhydrite, along the line of this great fissure, and of the known analogies of existing hot springs, Prof. Rogers says: "may we not even venture to imagine that the several gypsum-containing plains or valleys along the line of the great fracture, the Preston salt and plaster valley in particular, were so many basins, filled at times with turbid water kept heated and replenished by constant or by intermitting boiling springs and jets of volcanic steam charged with salt and sulphate of lime extracted from the rocks." Prof. Rogers sustains this probable suggestion by several sufficient chemical reasons, and ingenious arguments.

A report on the Geology and mining resources of that part of the Lackawanna Coal Basin which includes the lands of the Delaware, Lackawanna and Western Railroad Company, and those of the Lackawanna Iron and Coal Company in Pennsylvania, by the same able author, we are compelled to pass without further notice, although an abstract of its contents would not fail to interest and instruct our readers. Twelve overlaying beds of workable coals are described, with an aggregate least thickness of 54 feet, yielding 37½ feet of good coal, with a yield of 42,000 tons to the acre. Upon this solid foundation of prosperity, accompanied with abundant good iron ores and other minerals, the manfacturing town of Scranton has been built, and on a scale of magnitude unexampled hitherto in the United States.

5. *The Metallic Wealth of the United States described and compared with that of other Countries;* by J. D. Whitney. 8vo, pp. 510. Lippincott, Grambo & Co. 1854.—We have read this volume with pleasure and no small share of instruction. While, as its title implies, the main object of the author is to unfold the metallic resources of the United States, he has given us by way of comparison a connected and

as far as space and facts would permit, a complete view of the same resources in all countries. The plan of the work is simple and methodical. Each metal, beginning with gold and ending with iron, is taken up, and after a discussion of the mineralogical and geological occurrence of its ores, their distribution throughout the world is described, with more or less fullness, according to the importance of the subject. Carefully prepared statistical tables follow, showing the annual production both in quantities and values for all countries where it has been possible to procure accurate information. The work bears marks of diligent research both in the archives of mining and in the mineral districts themselves. A vast mass of valuable facts has been methodised, conflicting statements have been explained or set aside and the maze of local terms for values, quantities and qualities has been translated into intelligible English.

An introductory Chapter of 77 pages is devoted to a concise and clear explanation of the laws which characterize the deposits of the metals and their ores, and a brief description of the general methods followed in mining operations. This is a most useful chapter, and will be read with instruction by all who feel any interest in this great branch of our national wealth. In it the technical laws of the miner's art are explained, and clear ideas are given as to the various modes of occurrence of the useful ores and the importance in all mining operations of carefully recognizing these distinctions in their practical bearing.

Each mine in the United States is taken up under its appropriate head and described as completely as the materials which could be collected by personal examinations and from official or reliable published accounts would allow. In doing this the author does not withhold his opinions wherever he has deemed it advisable to express them. He alludes to the value of some of our metalliferous deposits with a degree of candor and sincerity which must command respect even where it fails to convince those of an opposite opinion. His remarks in the Introduction, upon the false and fraudulent schemes by which the public are deceived or swindled and the whole subject of mining brought into disrepute, will meet with universal approbation.

The Chapter on the Copper mines of Lake Superior contains a very complete summary of the progress and present position of the most remarkable mining development ever made in the eastern United States. The remarks on the present and future value of this region derive great additional interest from the intimate personal knowledge of the author respecting this remarkable region. The same may be said of the Chapter on the Lead districts of Wisconsin and Missouri, which are regarded as having reached their point of highest development and not as possessing in any respect the permanent character belonging to true veins. The data respecting the Iron manufacture of the world are particularly full and valuable. It is not possible in a short notice to review the contents of Mr. Whitney's able volume with such detail as to make them fully known. It is a book to be studied and will be on the table of every person who, from whatever motive, may desire to know our resources in metallic wealth.

A general summary at the close of the volume is given, accompanied by a tabular statement of the estimated amount and value of metals

produced throughout the world in 1854. The metals selected are gold, silver, mercury, tin, copper, zinc, lead and iron. The aggregate of these are as follows:

Gold.	Silver.	Mercury.	Tin.	Copper.	Zinc.	Lead.	Iron.
lbs. troy.	lbs. troy.	lbs. av.	tons.	tons.	tons.	tons.	tons.
481,950	2,965,200	4,200,000	13,660	56,900	60,550	133,000	5,817,000

The product of the United States in gold is set down at 200,000 pounds, Australia and Oceanica at 150,000, and Russia at 60,000, Mexico and South America 47,100. Of silver, the New World supplies 2,473,700, pounds, leaving only the small residue of 491,500 lbs. for all other countries. Of mercury, Spain gives the world 2,500,000 lbs. and the United States 100,000 lbs. England and Australia furnish over half of all the copper produced by the world: the present product of the United States being in this metal only 3,500 tons. Prussia and Belgium furnish four-fifths of all the zinc used in the world (viz. 16,000+33,600 tons.) Lead is distributed between Great Britain, Spain and the United States in the ratio of 4, 2, 1 (viz. 61,000, 30,000 and 15,000 tons each.) England furnishes more than half the Iron of the world, 3,000,000 tons, and the United States 1,000,000 tons. France is the next most productive country in iron, 600,000 tons. Russia produces but 200,000 tons, and Sweden 150,000 tons, quantities bearing a very small relation to the celebrity of product of those countries.

The following table exhibits the comparative value of the metallic productions of different countries, from which may be seen the ratio of their production, as compared, first, with that of this country taken as the unit, and, secondly, with that of Great Britain.

	Value of Metals produced.	Ratio of production to that of U. States.	Ratio of production to that of Gr't. Britain.
United States,	$79,827,000	1·	5·6
Great Britain,	96,169,800	1·205	·1
Australia,	39,428,000	·494	5·12
Mexico,	30,480,000	·382	1·3
Russian Empire,	25,240,000	·316	1·6
France,	15,252,500	·191	4·15
Chili,	13,144,000	·165	2·15
Rest of South America,	16,176,000	·203	1·6
Austrian Empire,	11,708,000	·147	1·8
Prussia,	9,680,000	·121	1·10
Belgium,	9,375,000	·118	1·10
Spain,	8,016,416	·100	1·12
Sweden and Norway,	5,460,896	·068	1·17
Saxony,	1,455,000	·018	1·67
Hartz,	1,147,588	·014	1·86
Italy,	832,500	·010	1·120
Switzerland,	375,000	·005	1·240

The great importance of our own metallic resources will be at once apparent from an inspection of the above table. It will be seen that we are second only to Great Britain in our production, as we are also in our consumption, of the metals. The two great Anglo-Saxon countries stand far before all others; and Australia, a colony of England of but a few years growth, is the next competitor on the list. As our production of gold which now forms so important an item of our metallic wealth, falls off, as it assuredly will, the deficiency may be more

than made up by the development of our resources for the production of other metals.

Mr. Whitney's work is certainly a most important addition to scientific literature, not merely in the English language but in all countries. It is a model of pure scientific style, and the mechanical part of the work is equalled only by the faultlessness of the proof-reading. In a pretty careful perusal of the whole volume we have failed to detect the first typographical error.

6. *City of San Salvador destroyed by an Earthquake.*—On the night of the 16th of April last, the city of San Salvador was completely destroyed by an earthquake. The population of the city in 1852 was estimated at 25,000. The following facts relating to the country and the catastrophe are cited from different sources.

The hills around the plain of San Salvador are covered with verdure, which, as the dews are considerable, keeps green through the dry as well as the rainy season. The city, with its white houses and churches, seemed, therefore, to be set in living emerald. About three miles to the westward of the city is the great volcano of San Salvador. The cone, which rises on the northern border or edge of the crater, is (approximately) 8,000 feet in height. The volcano proper, however, is a vast mass, with a broad base of irregular outline, its summit serrated by the jagged edges of the crater, and is much less in altitude than the cone. This cone seems to have been formed by ashes and scoriæ thrown out of the crater, which is represented as a league and a half in circumference, and a thousand *varas*, or three thousand feet deep—almost large enough to receive the whole mass of the volcano of Vesuvius. At the bottom of this crater is a considerable lake of water. Very few persons have had the temerity to venture into the chasm of the volcano, and none of these are likely, judging from the accounts which they give of their efforts, to repeat the undertaking. Two Frenchmen, who ventured down a year or two since, became exhausted and incapable of returning. They were rescued, with great difficulty, by a detachment of soldiers from the garrison.

The entire line of the coast range of mountains or hills, in San Salvador, bristles with volcanos. Thirty-five miles to the eastward of the city is the great forked peak of San Vicente, 10,000 feet in height; and thirty miles to the westward, on the same line, is the vast bulk of the volcano of Sta Ana with its dependent peak, the volcano of Isalco, which is in a state of constant eruption, and is called "El Faro de San Salvador," the Lighthouse of San Salvador. Besides these are numerous other volcanos, occurring, in conjunction with those just named, in the following order, commencing at the eastern extremity of the State: —San Miguel (active), Chinemeca, Sacatecoluca, Tecapa, Usulutan, San Vicente, San Salvador, Guasapa, Izalco (active), Sta Ana, and Apenaca, besides some others of less note, to say nothing of extinct craters, volcanic orifices, or extinct vents, which are now generally filled with water, constituting lakes without outlets, and of which the water is brackish. One of these, called "Joya," occurs about four miles to the southwest of the city of San Salvador.

It would be impossible to describe here the numerous active vents, emitting smoke, steam and sulphurous vapors, which occur at or near

the bases of some of these volcanos, and which are called "*Infernillos*," literally "little hells." There are, also, numerous other volcanic phenomena and results, of exceeding scientific as well as popular interest, but which it would exceed the scope of this article to describe adequately. In a word, it may be said with truth, that San Salvador comprehends more volcanos, and has within its limits more marked results of volcanic action, than probably any other equal extent of the earth. For days the traveller within its borders journeys over unbroken beds of lava, scoriæ and volcanic sand, constituting, contrary to what most people would suppose, a soil of unbounded fertility, and densely covered with vegetation.

San Salvador stands, or rather stood—for its destruction has been so complete as to justify the use of the past tense—upon a table land wholly made up of scoriæ, volcanic ashes, sand and fragments of pumice, overlying, to the depth of hundreds of feet, the beds of lava which had flowed from the volcano before their ejection. Those who have seen the scoriaceous beds, which buried Pompeii, can form an accurate idea of the soil on which San Salvador was built.

The channels of the streams are worn down to a great depth through this light and yielding material, and constitute immense ravines, which render the approaches to the town almost impassable, except at the places where gradual passages are cut down on either side, paved with stone, and sometimes walled, to keep them from washing out and becoming useless. Some of these approaches are so narrow that it is customary, when mounted, to shout loudly on entering, so as to avoid encountering horsemen in the passages, which are frequently so narrow as to preclude either passing or turning back. San Salvador has more than once owed its safety, in time of war, to these natural fortifications, which confounded the enemy with their intricacies and difficulties, while affording means of defense to the inhabitants.

The facility with which the soil above described washes away has been the cause of considerable disasters to San Salvador. During a heavy rain of several days duration, called a "*Temporal*," which occurred in 1852, not only were all the bridges which crossed a small stream, flowing through one edge of the town, undermined and ruined, but many houses destroyed in the same manner. One of the principal streets, extending into the suburbs, began to wash at its lower extremity, and the excavation went on so rapidly that no effort could arrest it. A considerable part of the street became converted into a huge ravine, into which the houses and gardens on either side were precipitated. The extension of the damage was guarded against, when the rains ceased, by the construction of heavy walls of masonry, like the faces of a fortification. How serious an undertaking this was regarded, may be inferred from the fact, that its completion was deemed of sufficient importance to be announced in the annual message of the President.—*Correspondence of the N. Y. Herald.*

The attention of the dwellers and sojourners upon the south-western part of that elevated plain which lies above the city of San Salvador, upon the 12th and 13th of April last, was forcibly called to a hollow, rolling, subterranean sound, which was repeated at intervals, and at

times continued several minutes without ceasing. It seemed to proceed from the mountain-chain, which extends southwesterly from the neighboring volcano, and forms a semi-circle. The awe-inspiring sound was most distinctly heard at Monserrat and at a little *hacienda* (farm) belonging to a German family, named Bogen, from East Prussia.

About 7½ o'clock on the morning of Good-Friday, (April 14,) two slight shocks of earthquake were felt at San Salvador, and in the immediate vicinity, succeeding each other with little interval, and followed some ten minutes later by one more severe. I saw the roof and walls of my little habitation trembling without at first perceiving the cause. "Es un temblos," said Martino, my young New-Spanish attendant, very quietly. He was a native of the country, and therefore accustomed to a phenomenon which fills the mind of an inhabitant of the North with such profound horror. The environs of San Salvador have a bad name throughout the country, on account of the frequent shaking of the earth, and the natives have given the region a name expressive of the fact. But though these slight shocks are constantly occurring, especially at the beginning and end of the dry season, (December and May,) there has never, since the memory of man, been any instance of these terrible catastrophes, which, as at Lima or Valparaiso, are expected about once in a century to overwhelm the city in total destruction. Beside, the volcano of Isalco, sixteen leagues south of San Salvador, being in constant activity, is considered as a sort of chimney, conducting off the vapors and liquid matter from the vast fires beneath, or, to quote Humboldt, as a safety-valve against destructive earthquakes.

The shocks continued throughout Good-Friday, with pretty regular intervals, about as often as two or three per hour, and having all the same direction, west-southwest to east-northeast. In this direction, at a distance of a short league from the city, and at an elevation of about 500 feet above it, is the great crater of Guscatlan. This crater seems to be of a more ancient formation than that of San Salvador, and is partly filled up by a lake. Here the shocks seem to originate, and not at the volcano.

In San Salvador, where the holy week is celebrated with all possible religious pomp, the people paid little attention to the earthquake that took place on Good-Friday, and were but to a very small extent hindered in their participation in the procession, and in their visits to the cathedral. Still, several times in the course of the day, as the shocks grew of greater force, the devout multitudes were seen flying from the holy halls, pale with terror, rushing in wild haste to the doors; their fear of the subterranean powers overcoming their faith in the celestial.

About 8½ o'clock P. M., the houses were shaken to their foundations, and the roofs began to crack. Walls were filled with fissures, the plastering fell from ceilings, and many tiles were thrown from the roofs. This shock lasted at least some eight seconds, with an undulating motion, and had the houses not been so exceedingly well adapted for resistance to earthquakes, they would probably have come down in masses. These houses are all low, very broad, and of only one story, the walls of loam-mud possessing considerable elasticity, and covered with flexible cane—no better construction being possible to meet the case.

Every body fled into the open air. An hour passed without further motion, yet most of the people resolved to put up their couches in their court-yards in the open air. The shocks continued more or less violent at intervals during the whole night; in the course of the twenty-four hours we counted forty-two distinct ones. On Saturday morning it became quiet again.

The capital of the State of San Salvador is situated at an elevation of 2100 Spanish feet above the Pacific, upon a most fertile plain, about 7 square leagues in extent, on the northwest side of which rises the volcano, hardly a league from the city. Seen from the town, the old fire-mountain forms a most beautiful cone, with a gently sloping summit, crowned to the highest peak with thick forest. The crater is perfectly well preserved, more than half a league in circumference, and partially filled with water. It rises about 1000 feet above the table-land on which it stands. The other hills, both those which belong to the volcanic range south, and those of the semi-circle above mentioned, rise not more than 1500 feet above the level of the plain.

There is no historical account of any period of activity in the volcano of San Salvador. There is a tradition, however, of an eruption of lava having taken place in 1659, which is said to have destroyed and covered with ashes the *pueblo* of Nehapa on the northwestern side. According to other traditions, this was no eruption of fire, but an overflow of mud from the crater.

Easter-Sunday was welcomed by the discharge of rockets and the music of the military bands, while the multitude moved in festive procession to hear high-mass in the cathedral. Most of the houses were beautifully decorated with pisang leaves and branches of palm trees. The "Sanctissimum" was carried in triumph through the streets. A long procession followed, and the senoras and senoritas displayed their most splendid toilets. In the afternoon, the grand procession of saints took place. Colossal statues of saints, carved in wood, and most luxuriously equipped in costly silk dresses, were carried from the churches through the streets; and wherever they chanced to meet, the processions stop to give the saints an opportunity to embrace. The multitudes greet these scenes with extravagant delight, and rockets by the hundred are sent rushing through the air. The good Catholic people devote themselves upon Easter-Sunday, first to religious exercises, then to cheerful enjoyment; and so the day concluded with music, fireworks, and banqueting.

Soon after 9 o'clock in the evening, came a severe shock, more powerful than the severest on Good-Friday, accompanied, during its entire continuance, by a hollow, rumbling noise. Walls tottered to their foundations, bricks and tiles fell to the earth, and many houses were rent with fissures. I was lying in bed, suffering under an attack of ague, and had fallen into a feverish slumber, from which the noise awakened me. At that instant a portion of the ceiling of my room fell, beating me upon my head and face, and for some minutes blinding me with dust. I sprang from my bed, and groped my way in the darkness to the door, which was unfortunately locked. I succeeded at length in finding it, and reached the court-yard in safety, where I found all the other inmates of the house assembled, crying and praying in a breath.

In a few minutes, though, the panic was over again, and one heard even laughter and joking at the sudden consternation and flight from the house. These frightful phenomena occur too often to rouse more than a passing anxiety, even when the shocks are of unusual strength. They seem to be content if their dwellings do not sink at once. Still, the inmates of the houses brought their beds into the open air, and opened the doors of their houses. My next neighbor, a young doctor, remarked, that probably no other severe shock would occur that night; to which a Catholic priest replied, that the house was old, the roof rotten, and caution was at all events commendable. The people of the house went in again, and with open doors returned to their Easter feast, the conversation for the next hour turning almost exclusively upon the horrible "temblos."

In the mean time, I, being sleepless, was looking out upon the nightly sky. The day had, as usual, been very warm; the thermometer rising at noon to 88° Fahrenheit. Heaps of cloud (cumulo-stratus) were piled up mountain-like about the declining moon, but at about 10 o'clock disappeared. The moon was now shining merrily through a clear and calm atmosphere, a few vaporous veils of cloud (cirrus or cirro-cumulus) only, still hung immovable about some points of the horizon. Nothing appeared in the atmosphere to announce any uncommon phenomenon.

Half an hour later, (10½ P. M.) came the frighful shock which laid San Salvador in ruins. It began with a loud noise and undulating motion, the ground moving as if shaken by a subterranean sea. This motion, with its accompanying subterranean thunder, in the same direction with the previous shocks, lasted some ten or twelve seconds. The cracking and falling of roofs made a roar through which the appalling sounds below could scarcely be heard. A colossal cloud of dust arose. The terror, the cries and lamentations of the people were beyond description. Then followed prayers and a universal, loud, wailing invocation to *Maria Sanctissima* and all the saints, and finally a low, lamenting, and supplicating song from thousands of voices rising simultaneously from all the places of refuge to which the multitude had fled for safety.

And now began a scene which my pen is unable to describe. How insignificant appeared now the most frightful points in my past life! how mean appeared all the episodes of war and revolution which I had witnessed in the Old World! There, one had to deal with known agencies, with adversaries of flesh and blood, and not, as now, with unknown powers of the depths of whose existence we hardly are aware.

The shocks continued, sometimes light and sometimes with fearful force, with but short intervals, throughout the night and the next day, at the evening of which their number amounted to 120. I can compare the awful rumbling noise attending them only to heavy discharges of artillery in some subterranean battle. Sometimes the noise was more of a rattling character, and the ground waved for minutes without a real shock. No one thought of goods and chattels; the people trembled still for their lives; the motion of the ground had opened it in all directions, and no one knew but that the next moment a yawning chasm would open beneath his feet and swallow him for ever. After each

succeeding shock the multitude changed their prayers, and called upon some new saint for help. But whether the saints did not hear, whether they could not or would not help, the earth continued to tremble, the subterranean artillery to roar. A few hours more, and the more resolute had become accustomed to the roar, and began to take measures for the public safety, the ravages of the Indians being feared.

About 1 o'clock in the morning, a gentleman of my acquaintance climbed over the ruins of my house into the yard to look after me. Seeing me somewhat better, he proposed a walk in the moonlight through the town. We went first to the market-place. The cathedral was still standing, but the town, I now saw, was involved in one general ruin; not a single house had resisted the last frightful earthquake! The cathedral—a more elegant than imposing building, of the last century—had to a certain extent sustained the shock. But its belfry had been thrown down, its porch was in ruins, its walls were cracked and full of fissures. All the other churches, save that of the old Franciscan convent, had suffered far more severely, and their interiors presented sad pictures of solitude and ruin, being covered with dust and rubbish from the fall of tiles and stones from the heavy roofs. Colossal statues had tumbled from their pedestals, and their splendid and gorgeous robes were dragged in the dirt. There they lay, utterly uncared for by the multitudes who the day before had carried them in triumphant procession. Life and property were at this moment of more importance than images, the worship of which had done so little to arrest the footsteps of the calamity. A wing and a newly finished tower of the university still stood, and strangely enough, the clock was still striking the hours with all due regularity. In the Episcopal palace the ceiling had given way, and the bishop, Don Tomaso Saldana, a man justly admired for his piety and virtues, had fared no better with his consecrated head than we profane. Señor Duenas, ex-President of the Republic, once a monk, then lawyer and diplomatist, and incontestably in capacity the first man in the country, was somewhat more seriously injured.

The streets were now deserted, save by military guards posted here and there, and we found our progress much impeded by the piles of ruin and rubbish. Inside the houses was the quiet of death. The people, fearing to remain even in the widest streets, had collected, high and low, rich and poor, and were seated upon the ground in the centers of the public squares. The stiff Spanish etiquette which generally so completely divides the several ranks of the population, was completely forgotten in this night of terror. Rich men and beggars joined their tears, their cries, their prayers, supplications and hymns, at each new shock of more than common severity.

Don José Maria San Martin, the recently elected President of the Republic, exhibited great presence of mind and resolution, and gave wise and energetic directions for the protection of property. At the corner of the cathedral we met the Franciscan monk, Don Estavan Castillo, a beloved acquaintance of ours, a member of one of the first families in the country. He is the most ingenuous and remarkable man whom I have met in Central America, extremely inquisitive, much given to philosophical speculation, and the possessor of one peculiarly

characteristic trait in common with Pascal; he delighted to talk of the great mysteries of the world, those upon which the thinkers and philosophers of all nations and ages have speculated in vain. Our last conversation on the blind ruling of the powers of Nature seemed singularly adapted to the scene which surrounded us now. The monk pressed my hand in silence. He, with a band of strong fellows, was engaged in a search for persons buried in the ruins, while the bishop and all the clergy of the higher ranks had fled to Cojutepeque. At day-break, already a hundred bodies had been drawn from the rubbish, but what the real number of deaths was I have not yet been able to learn. That several thousands were not killed, we must attribute to the caution inspired by the severe preliminary shock above mentioned; nor in all probability, would the writer of these lines, without that warning, have ever held the pen again, as the last principal shock brought down the heavy ceiling of his dwelling.

On Easter-Monday the rising sun illuminated a most sorrowful scene. The inhabitants, pale with fear and fatigue, were wandering at random through the town without shelter or place of rest. The greater part fled in the direction of Apopa and Cajutepeque, leaving every thing behind. Among the women, who were mostly in extreme négligée, I noticed the wife of the President, entreating her husband to flee also from this place of horror. The President, however, remained faithful to his duty, and continued to act with energy. Most of the State prisoners perished, owing to their inability to leave their rooms; and in one case where two were chained together, one was killed, and the other forced to bear his body until relieved of his horrid burden by some police officers. A court-martial held under a tent in the University-place, sentenced every thief caught in the act of stealing and proved guilty by two witnesses, to be shot.

The ruins of San Salvador no longer affording me shelter, I returned next morning to the *hacienda* of an acquaintance on foot, as all the mules had either been stolen or were fully employed by the merchants in removing goods, and therefore not to be procured for any amount of pay. During my walk thither there were four shocks, one of which was one of the severest of all, lasting about seven seconds, and being accompanied, as usual, by a loud detonating sound, just like the noise accompanying the vollies at Vesuvius, to one standing near the crater at a time when volumes of smoke and stones are hurled into the air. My convictions grow stronger every moment that the seat of this subterranean action is very near, and that the vapors and glowing masses of the depths are seeking some new outlet.

Every fugitive of whom we asked the reason of this hurried flight, going off as they did with no thought of even the most necessary articles of comfort, answered alike, that after the destruction of the town, the bishop had said, that the entire region around San Salvador would, "before another moon had passed, sink into the depths of the earth." This prophecy has not, however, been fulfilled. The new moon is shining upon the ruins of the town, and upon the haciendas scattered over the plain. But the earthquakes and the subterranean noises still continue, and upward of a hundred shocks are felt each day. In all probability the powers below are striving to burst the crust of the earth,

and build up a new chimney for their gases, vapors, and molten masses. Woe to him who lives within the reach of the new crater.

P. S.—A month has passed since the above sketch was written. The shocks have decreased in number and intensity, but still they are occasionally felt, and the sounds below are heard. None but the poorest of the population of San Salvador have ventured to return to their former habitations.—*M. Wagner, in N. Y. Tribune.*

III. Botany.

1. *Hooker's Icones Plantarum*, vol. x, plates 901–1000. (London, Pamplin, 1854.)—This volume closes an important work, which, like most botanical publications not of an elementary character, in England especially, has been carried on at a heavy pecuniary sacrifice on the part of the liberal and distinguished author. This last volume is exclusively devoted to Ferns, can be purchased separately, and makes a *pendant* to Sir William Hooker's Species Filicum, being of the same 8vo size. Three of our own rare Ferns are figured in this volume; viz., *Asplenium pinnatifidum*, Nutt.; *Anemia Mexicana*, Klotzsch (No. 572 of Lindheimer's Texan collection, and No. 826 of Wright's); and the pretty little *Trichomanes Petersii*, described last year in this Journal. A. G.

2. *J. D. Hooker's Flora of New Zealand*, part 6, published in June, completes the account of the true *Mosses*, by Mr. Wilson, and contains the greater part of the *Hepaticæ*, which are elaborated by Mr. Mitten. Thirteen more plates are devoted to Musci and Hepaticæ, and about six species are illustrated on each plate. The remaining plates are devoted to Fungi and Algæ. A. G.

3. *Genera Plantarum Floræ Germanicæ Iconibus et Descriptionibus Illustrata.*—This well-known work, begun in 1833 by the late Th. Nees von Esenbeck, continued after his death by Prof. Spenner, after his death by Putterlick and Endlicher down to fasc. 24, and since their decease suspended for several years, is now "conjunctis studiis plurium auctorum continuatum." We have seen nothing of fasc. 25 and 26, but are told that they were issued a few years ago, edited by Prof. Schnizlein. Fasciculus 27, published in 1853 by R. Caspary of Berlin, has come to hand, and comprises 16 genera of *Cruciferæ*, one of *Ranunculaceæ* (Caltha), and 2 of *Papaveraceæ*. The letter-press is for the most part increased to four pages for each genus, and one or two genera have two plates devoted to their illustration. The plates, 20 in number, are crowded with details, particularly of the ovules, ovary, and embryo, and are apparently extremely faithful, but not very elegant, owing to the style of engraving adopted. Fasc. 28, by Prof. Schnizlein of Erlangen (1854), is devoted to several of the earlier monopetalous orders: the letter-press and the plates accord with those of the later preceding parts, and have none of the elaborate details of development given by Caspary. There is some prospect that this valuable work will now go on steadily. We wish we could say as much for the similar undertaking in our own country. A. G.

4. *Floræ Danicæ Supplementi fasciculus I*, 1853.—This great national work, carried on from 1761 to 1845, and comprising 14 folio

volumes with 2460 plates, is to be extended, at the suggestion of Prof. Fries, so as to embrace Swedish and Norwegian plants not already figured. Professor Liebmann is the editor. The 1st fasciculus of this supplement contains 60 plates, a great part of them containing two plants, very faithfully represented. Almost all the species belong also to the boreal American flora; which gives to the work a peculiar interest in this country. A. G.

5. *The Micrographic Dictionary*, by Drs. GRIFFITH and HENFREY, part II. (June, 1854) has been received from the enlightened and tasteful scientific publisher, Mr. Van Voorst (whose name, by the way, is most deservedly commemorated by a beautiful new genus of the network or lace-like Algæ, recently discovered on the south-shore of Ceylon, by Dr. Harvey). The Introduction (pp. xxv–xl), here brought to a close, treats of *illumination* for the microscope, under various circumstances, and of the methods of *microscopical analysis*, or of determining the structure of microscopic objects, from the appearances which they present under various conditions; of *chemical reactions*, and of *measurement*. The Dictionary, pp. 17–32, extends to the article *analytic crystals*. Of the engraved plates there are two (colored) of *Desmidaceæ*, one of *Diatomaceæ*, one exhibiting the microscopic structure of hairs, and one of *Infusoria*. Evidently the work fulfills its promise, and will be a vade-mecum of the microscopist and general naturalist. A. G.

6. *Linnæa: ein Journal für die Botanik: herausgegeben von* D. F. L. VON SCHLECHTENDAL, which was said to be suspended, now goes on again with renewed spirit. The 26th volume (the 10th of the new series) bears the date of 1853; but the 1st part was not published (as the cover properly informs us) until February, 1854, the second, in April. The two parts received contain a monograph of the small group of *Stackhousiaceæ*, by T. Schuckardt; an elaborate disquisition on *Bouvardia*, and the first page of a critique upon the genera *Panicum* and *Paspalum* in Steudel's new Synopsis Plantarum Glumacearum, by the editor; an attempt at a new arrangement of *Gesneriaceæ*, by Hanstein; continuations of *Plantæ Mullerianæ* (Australian) and *Plantæ Wagenerianæ Columbicæ*, by various authors, and one or two smaller contributions. We hope this long-established and valuable Botanical Journal will now go on with regularity and success.

The *Botanische Zeitung*, a weekly Gazette, edited by von Schlechtendal and von Mohl, now in its 12th year, is well sustained. Its principal articles are upon vegetable anatomy and development, thus leaving the pages of the Linnæa clear for memoirs and longer papers on systematic botany.

A rival German Botanical gazette, now in its second year, is the *Bonplandia; Zeitschrift für die gesammte Botanik*, edited by B. SEEMANN, in London, but published at Hannover, a sheet of 8 or occasionally more pages, in small folio, issued on the first and fifteenth of every month. It is handsomely printed, and is valuable for intelligence. Of late there is some unpleasant controversy between it and the Botanische Zeitung, which is to be regretted. A. G.

7. *Annales des Sciences Naturelles*, etc., *redigée pour la Zoologie par* M. MILNE EDWARDS, *pour la Botanique par* MM. AD. BRONGNIART

et J. Decaisne.—The twentieth volume closes the third series of this most important of natural-history periodicals; and a fourth series commences with the year 1854. The only fault to be found with the work is, that it is, as usual, behind date, only three monthly numbers having as yet appeared during the current year. But this is much better than in former times, when it had fallen almost a twelvemonth behind. Of the Botanical volumes, the most important articles within the last three years have been: Naudin's monograph of the Melastomaceæ of the Paris Museum, an elaborate revision of the family; Tulasne's papers on the *Antidesmieæ*, on the Ergot of Grasses, the reproductive organs of Fungi, and especially his full and incomparable memoir on the Organography of the *Lichenes* (embracing 240 pages of letter-press and 16 well-filled and admirable plates); Thuret's fine researches upon the antheridia of Cryptogams, especially of the Algæ, &c.; a series of very important papers by Trécul on the origin and development of ligneous fibres in the stems of plants, the mode of increase of dicotyledonous stems in diameter, and on the formation of leaves (in all which the author is winning a high reputation as a vegetable anatomist); some good papers by Garreau on what he calls, perhaps with good reason, the respiration of plants, he confining this term to the decomposition of vegetable products and the conversion of carbon into carbonic acid, which he shows to go on at all times, while the plant is effecting any transformations, although masked in the foliage, under sunshine, by the vast predominance of the opposite process (in which *vegetation* consists); an admirable investigation, by Boussingault and his assistant Léwy, of the composition of the air contained in a fertile or manured soil, showing that the roots of our esculent plants and grain, as ordinarily cultivated, are surrounded by an atmosphere which contains from 20 to more than 240 times more carbonic acid gas than the exterior atmosphere (the direct bearing of which against certain views too hastily propounded by Liebig, in former years, is abundantly evident); some good papers by M. Payen, on the organogeny of the flower in several families; and an article by Lucaze-Duthiers on the nature and development of galls and other abnormal productions of plants caused by the puncture of insects, &c.

The two fasciculi of the 1st volume of the fourth series contain some papers of descriptive botany; one by Groenland of Altona on the germination of certain Hepaticæ, beautifully illustrated; one by Trécul, elaborately investigating the formation of vessels and the so-called radicular fibres under adventitious buds, explaining quite differently from M. Gaudichaud the well-known facts which found their readiest explanation according to the theoretical view of the latter; this is illustrated by three admirable plates. M. Dareste endeavors to prove, with some success, that the red and yellow hues of the Chinese sea are due to the presence of a microscopic Alga, probably identical with the *Trichodesmium erythræum* of Montagne, from which the Red sea derives its occasional hue, and, it is thought, its name. A. G.

8. *Mammoth Trees of California.*—Some details may be expected, from the writer in the Sonora Herald cited in the last number of this Journal, respecting several large Coniferous trees in California. Mean while, it may be well to state, first: that the hollowed section of a

trunk exhibited last winter in Philadelphia, and which furnished the principal data of the estimate published in the May number (p. 440), was not taken, as we were led to suppose it was, from the famous giant "Wellingtonia" felled near the head of the Stanislaus river. We learn that it came from a less gigantic tree, which grew much nearer to San Francisco, and that the tree was a true *Redwood* or *Sequoia sempervirens.*

(2.) This tree, although considerably smaller, is apparently as old as, and probably older than the great Wellingtonia, although doubtless not surpassing the estimate already given. For, whereas its oldest wood exhibits about 48 layers to an inch, that of the Wellingtonia, of which we now have specimens, has as few as 25 or 20, or even fewer layers to an inch, at or near the circumference. Moreover, Dr. Torrey has recently had an opportunity to count the layers on a complete radius of the trunk of the famous Wellingtonia now exhibited in New York, and he finds that they are only 1120 in number! From the data which Dr. Torrey has furnished we find that, on the radius examined, the 1st hundred layers occupy a breadth of 17½ inches.

2d	"	"	"	14	"
3d	"	"	"	12½	"
4th	"	"	"	13	"
5th	"	"	"	16¼	"
6th	"	"	"	8¾	"
7th	"	"	"	7¾	"
8th	"	"	"	11	"
9th	"	"	"	10	"
10th	"	"	"	11	"
11th	"	"	"	11¼	"

The remainder of 20 layers occupies over 1 inch.

Eleven hundred and twenty layers on the semidiameter of 135 inches, or 11 feet 3 inches. We had ventured to reduce by more than one-third the accredited statement or estimate that this tree was 3000 years old. The facts show that the tree lacks almost three centuries of being half as old as it was said to be! Its enormous size is owing to its continued rapid growth rather than to any very extraordinary age.

(3.) A comparison of the cones of the two brings to view no adequate generic differences between the *Wellingtonia* of Lindley and *Sequoia.* Unless the male flowers furnish characters, the so-called Wellingtonia will hereafter bear the name imposed by Dr. Torrey, namely that of *Sequoia gigantea.* The flowers, however, are still a desideratum.

A. G.

9. *On the Fossil Plants found in Amber;* by Professor Goeppert, (Berlin Academy, Bulletin, 1853, pp. 450–476; Edinb. N. Phil. Jour., lvi, 365.)—Since Prof. Goeppert recognised the *Taxodites dubius* of Sternberg, which occurs abundantly in the plant-bed at Schosnitz, Silesia as the *Taxodium distichum*, Rich., now living in the southern parts of the United States and in Mexico, and found also some fossil Plants from Schosnitz to be identical with living species, thus pointing out the identity of some tertiary plants with the living, he has had the opportunity of examining a collection of 570 specimens of Amber, containing plant-remains, belonging to M. Menge of Dantzig, and 30 specimens

beqneathed by M. Berendt. With these the author has been enabled to raise the number of the species of plants in the Amber Flora from 44 to 163, of which only *Libocedrites salicornioides* and *Taxodites Europæus* occur fossil out of the Amber, and 30 are identical with existing species. The constitution of the Amber Flora, as at present known, is shown in the following table.*

	Number of Species.	Number identical with existing Species.
PLANTÆ CELLULARES.		
I. Fungi	16	4, certainly; perhaps all.
II. Algæ	1	1
III. Lichenes	12	6 or 7 (with species on the E. and W. coasts of Arctic America.)
IV. Musci hepatici: Jungermanniæ — 39 specimens	11	11
V. Musci frondosi	19	2 or 3, certainly; perhaps all.
PLANTÆ VASCULARES.		
III. Cryptogamæ (Acotyledones.)		
Filices.		
Pecopteris Humboldtana, *Göpp. & Behr.*		
IV. Monocotyledones.		
Cyperaceæ.		
Carex eximia, *Göpp. and Menge.*		
Gramineæ.		
Fragments.		
Alismaceæ.		
Alisma plantaginoides, *Göpp. & Menge.*		
V. Gymnospermæ.		
Cupressineæ	20	2
Abietineæ	31†	1
Gnetaceæ	1	
VI. Monochlamydeæ.		
Betulaceæ	2	
Cupuliferæ	10	
Salicineæ	3	
VII. Corolliforæ.		
Ericineæ	22	3
Vaccineæ	1	
Primulaceæ	2	
Verbasceæ	2	1
Solaneæ	1	
Scrophularineæ	1	
Lonicereæ	1	
VIII. Choristopetalæ.		
Lorantheæ		
Crassulaceæ	1	1

The whole Flora as yet known includes 24 Families, 64 Genera; comprising 163 species.‡

The following are the general results of Prof. Goeppert's researches.

A considerable number of tertiary species of plants (especially *Plantæ cellulares*) are still living.

* For the lists of genera and species, see the works above referred to.

† Of these, eight (the species determined from the fossil wood) afford Amber.

‡ The number of species may probably be raised to about 180, by additions from about 50 specimens of which the relations are barely determinable.

The flora of the Amber being destitute of tropical and sub-tropical forms, it is to be referred to the Pliocene period.

The remains only of forest-plants have been preserved in the Amber. This flora much resembles the present, especially in the Cellular plants; the *Cupressineæ*, however, are now almost wholly wanting in our latitudes, and the *Abietineæ* and the *Ericineæ* are not abundant. The four species, of *Thuia*, *Andromeda*, and *Sedum*, which are identical with the living, are indeed northern forms; on the other hand, the *Libocedrus Chilensis* is found on the Andes of Southern Chili.

The flora of the northern parts of Europe, Asia, and America, is at present less rich in species of *Cupressineæ* and *Abietineæ* than that of the Amber, although it possesses some of the species found in the latter; nor are the existing northern species of *Coniferæ* so rich in resinous products as were the trees of the Amber Flora with which the *Dammara Australis* of New Zealand can alone in this respect be compared, the branches and twigs of this tree being stiff with white resin-drops.

If we take into consideration the enormous extent which the forests of

Abies alba,	Abies balsamea,	Abies ovata,	Larix Sibirica, and
—— nigra,	—— Sibirica,	Larix Dahurica,	Pinus Cembra,

at present attain in North America and Northern Asia, we are led to infer a similar extension in former times of the Amber-forests throughout the northern regions; to which, indeed, the wide distribution of amber in the late tertiary deposits of North America, Holland, North Germany, Russia, and Siberia to Kamtschatka, bears evidence.

If we judge from the proportion which the fir-forests bear to the trees of our northern flora generally, we shall infer, from the prevalence of the *Coniferæ* in the Amber, the existence of a very rich flora contemporaneous with the latter, and of which but a small part has as yet been presented to our notice. Germany contains 6800 species of *Cryptogamæ*, according to Rabenhorst, and 3454 species of *Phanerogamæ*, according to Koch. The proportions are—

	THE GERMAN FLORA.			THE AMBER FLORA.		
	Classes.	Species.		Classes.	Species.	
Cryptogamæ	8	6800		6	60	
	Families.	Species.		Families.	Species.	
Phanerogamæ	135	3454		20	102	
Cupuliferæ	..	12		..	10	
Ericineæ	..	23		..	24	
Proportion of trees and plants	$\left\{\begin{matrix}333\\3121\end{matrix}\right\}$	=1 : 10		$\left\{\begin{matrix}94\\9\end{matrix}\right\}$	=10 : 1	

Amber is never found isolated in large or small masses in the bituminous wood of the Brown-coal with resin-ducts of a single row of cells, which never contain yellow masses of resin, but only dark-brown transparent resin-drops, as in the *Cupressineæ* or the *Cupressinoxylon*, of Goeppert. The compound resin-ducts of the *Abietineæ* alone are filled with amber.

It is probable that the amber and its plant-remains have been drifted to the places in which they are now found. The author knows of no well-authenticated instances of the occurrence of amber in the Brown-coal formation itself; it occurs in the drift-beds above it, where, how-

ever, it does not appear to have originally belonged. Scheerer has found it in Norway; Von Brevern, at Gischiginsk in Kamtschatka; Rink, in Haven Island, near Disco Island, Greenland; and in these instances it is generally in drift-beds. The supposition, however, that it belongs to the Drift-period is difficult to substantiate, the flora of that period being as yet but little known. The stomach of the fossil Mastodon found in New Jersey contained twigs of *Thuja occidentalis* (found in the Amber-flora); and in the Erie Canal in New York State, at a depth of 118 feet there have been found freshwater shells, together with portions of *Abies Canadensis*, which still grows in the neighborhood, and leaves of which are still recognised (though with some doubt) in the amber. The fossil wood of the Drift-beds of Siberia, also, is nearly related to that of the present day.*

The height at which amber is found at the Castle on the Riesengebirge near Helmsdorf is nearly 1250 feet [German] above the sea level, and at Grossman's Factory near Tannhausen, at 1350 feet.

The amber is not derived from one species of wood only *(Pinites succinifer)*, as Professor Goeppert formerly thought, but also from eight other species, including the *Pinus Rinkianus*, in which Vaupelt observed the amber of Disco Island.

It is probable that all the *Abietineæ*, and perhaps the *Cupressineæ*, have furnished their share of the resinous matter (at first consisting of various specifically different resins) that afterwards by fossilization becomes amber; and this is supported by the author's experiments in the formation of amber from resin by the wet process, as in his experiments on the formation of coal from recent plants.†

In form the amber is either like drops, indicative of a former semifluid condition, or as the casts of resin-ducts and cavities. Large nodular masses occur, which must have been accumulated in the lower part of the stem or the root, as in the Copal trees.—*(Quarterly Journal of the Geological Society*, vol. x, No. 37.)

IV. Astronomy.

1. *New Comet*, (Gould's Astron. Journal, Aug. 11.)—A comet was discovered by Klinkerfues, at Göttingen, June 4, 1854. The following elements of its orbit were furnished by Prof. R. Keith, of the Washington Observatory, from observations at Bonn, June 11, and Washington June 26 and July 11.

Perihelion passage,	1854, June 21·7751.	
Longitude of perihelion, - -	273° 6′ 52″·4	Mean eqx.
" " asc. node, - -	347 40 8 ·0	1854·0
Inclination, - - - - - -	71 18 46 ·0	
Log. cos. φ, - - - - -	8·635714.	
Log. q, - - - - - -	9·811593.	
Motion	Retrograde.	

2. *Orbital Elements of Bellona and Amphitrite*, (Comptes Rendus, June 19, 1854.)—The following elements of the new planets *Bellona* and *Amphitrite* are computed by M. Oudemans, of the Observatory of

* See Quart. Journ. Geol. Soc., vol. vi. Part 2. Miscell. p. 66.—Transl.

† Ibid, p. 33.—Transl.

Leyden: the first from observations of March 1 at Bilk, April 12 at Berlin, May 26 at Leyden; the second from observations of March 1, at London, April 11 at Berlin, May 31 at Leyden.

Epoch, March 0, m. t. Berlin.

	Bellona.	*Amphitrite.*	
Mean anomaly, . .	39° 19′ 3″·13	127° 23′ 56″·9	
Longitude of perihelion,	117 23 5 ·6	54 4 26 ·2	M. eqx.
" " asc. node,	144 57 56·3	356 15 54 ·6	1854·0
Inclination, . .	9 27 16·15	6 4 6 ·35	
Angle (sin = excen.) .	9 53 4·50	3 55 43·	
Log. mean daily motion,	2·882097	2·941143	
" semi-axis major,	0·445273	0·405909	

V. Miscellaneous Intelligence.

1. *New Process for Desulphurizing Metals.*—Dr. Homer Holland has presented a process for separating gold from ores of copper, iron, &c., with which it is found associated. It consists in the employment of nitrate of soda with heat. The ores in a state of fine division are mingled with pulverized nitrate of soda in atomic proportion to the sulphur of the ores. The reaction is between two atoms of oxygen from the salt and the sulphur to form sulphurous acid, which may be saved for making SO_3 in the ordinary chambers. The nitrogen escapes as an effete product, and sulphate of soda with sulphate of copper, oxyd of iron and metallic gold remain in the dry mass. A very gentle heat suffices to bring on the action. The resulting dry mass soon falls to powder under the influence of the air, and is lixivated to separate the soluble sulphates. The copper may be separated by the action of scrap iron, or if very abundant may be crystallized from the mother liquor as blue vitriol. The gold is left in the lixivium by this process in a condition remarkably adapted to speedy and perfect amalgamation by mercury, for which purpose any of the machines now in use may be employed. The application of this process upon a large scale will depend upon the ability to procure an ample supply of crude nitrate of soda, abundance of which is said to exist in the province of Iquique.* Dr. O. M. Lieber, who has published a report upon Dr. Holland's process, states that by it he obtained quantities of gold from the tailings of the best amalgamators, greater than had been previously separated from the entire ore. It is well known that the sulphurets of the North Carolina gold-bearing quartz are all auriferous, but the gold exists in such a state, whether mechanical or chemical, is perhaps hardly settled, that it cannot be removed by the ordinary use of mercury. In such cases Dr. Holland's process seems to be peculiarly valuable. Its use for ordinary copper ores appears to be less promising, owing to the present cost of nitrate of soda.

2. *Separation of Nickel and Cobalt by Wöhler's process*, (communicated by Francis E. Dakin, Albany University.)—Having a solution of nickel and cobalt in hydrochloric acid, precipitate by potassa, filter, redissolve in cyanid of potassium, add peroxyd of mercury, triturated in water, little by little till in excess, boil half an hour, filter, wash, dry

* See John H. Blake, this Journal, [1], vol. xliv, p. 1.

and ignite till all the mercury as well as the cyanogen is expelled, leaving pure oxyd of nickel. Precipitate the cobalt by hydrochloric acid, filter, wash, dry and ignite as before, and thus obtain the oxyd of cobalt.

3. *Researches on the Tides of the White Sea.* 2d Memoire; by M. Talyzine, (L'Institut, No. 1044, Jan. 4, 1854, p. 7, St. Petersburg Ac. Sciences.)—In this Second memoir, the author applies himself chiefly to the rise and fall of water during the flood and ebb in the River Kuja, and indicates the mode of observation he adopted. By comparing observations and seeking to unite them by a formula, he has found that the oscillation of the water of the river is composed of three partial oscillations. The first of these has a period equal to that of the flood and the ebb; it may have a height of 30 inches. He calls it the semi-diurnal oscillation. The second has a period which is only the half that of the flood and ebb, it has a height of 5·8 inches. The third has only the third of the period of flood and ebb; it has a height of 3·8 inches. The high waters of the 3d oscillation happen later than those of the 1st by a very considerable quantity, whilst those of the 1st and 3d almost coincide. On tracing the curve representing the rise of water, a period of inflection is seen to belong to this line, which seems to indicate that in the phases of the tide which correspond to it, the water rises more slowly than elsewhere. But this inflection represents the phenomena, called (*manicha*) the stand, and which consists in this, that near the middle of the tide-wave the water ceases to rise and after remaining for some time at the same height, slowly falls. These phenomena are always attended by another which forms an exception to the ordinary flood and ebb. It is known in fact, that between headlands and at the mouths of rivers, the ebb lasts longer than the flood. This also takes place in the White Sea, in localities where there is no stand (manicha). But in localities where it exists the contrary takes place, the flood lasts longer than the ebb, and in the river Kuja this period is an entire hour. It is the 2d and 3d oscillations which cause this predominance of flood over ebb, and M. Talyzine seeks to decompose these influences. On examining the curves of projection, it appears that *the stand* should depend on the second oscillation; in fact, if the high waters of the 2d come later than those of the 1st there ought to be a stand, and if they come sooner this phenomenon should vanish. The examination of the curve of the 3d oscillation seems also to indicate a slackening in the rise of the water, but this delay differs from the stand, because the duration of flood equals that of ebb, for this oscillation has no influence on this duration. Finally by combining the curves of these two oscillations, it appears that the 3d increases the inflection of the 2d, that is, the delay in the falling of the water. From all these considerations, it results that the stand arises from the high waters of the 2d oscillation coming later than those of the 1st, and that the 3d increases the stand produced by the 2d. E. B. H.

4 *Application of the electric telegraph to the determination of the difference of longitude.*—On Nov. 25, operations were commenced for determining the difference of longitude between Brussells and Greenwich by electric telegraph. Three or four days sufficed for connecting the Brussells Observatory with the central station of that city, and to es-

tablish immediate correspondence by this station with the Royal Observatory of England. Some details on this subject follow.

Signals were made every evening between 10^h and 11^h, amounting to about 150 per hour. The first portion of these operations needed not to extend beyond three days; but as the state of the sky, especially in England, did not permit the making of the requisite astronomical observations for properly regulating the clock rates, a condition absolutely essential in this delicate enterprise, the operations were necssarily continued, and even probably prolonged until the evening of December 4, so as to give over 1200 signals. The astronomical observations at Brussells were very numerous, but while in that city the weather was magnificent, the sky at Greenwich was almost constantly overcast. M. Quetelet sent thither M. Bouvy, one of his aids, while Mr. Airy, Astronomer Royal of England, sent Mr. Durakin, one of his aids, to Brussells. The two aids are now to return to their respective posts, and will recommence a new series of electric signals and astronomical observations to eliminate the effects of *personal equations.* Every night, precisely at ten, Brussells mean time, four signals given at three seconds interval, announce that the English observers are at their post. Thirty seconds after, four like signals sent from Brussells, also announce the presence of the Belgian observers. At $10^h\ 1^m$, Greenwich begins to give signals at 10 or 16 seconds interval, but first making known the number of stars observed during the evening by as many 3^s interval beats. Brussells operates then in like manner from $10\frac{1}{4}^h$ to $10\frac{1}{2}^h$, when Greenwich resumes, and then Brussells at $10\frac{3}{4}^h$. The signals have never seemed to lose any of their intensity, in spite of the distance between Greenwich and Brussells; and considering the extraordinary velocity of the galvanic current, we may say that the needles of two galvanometers, placed in the two observatories, traverse simultaneously, and move parallel to each other.

M. Quetelet thought that in his communication to the Academy he ought to limit himself to these simple indications, leaving to Mr. Airy the care of discussing and publishing hereafter the aggregate of the observations undertaken at his request. E. B. H.

5. *Paris Observatory.*—Since the decree of reorganization of the Paris Observatory, several official acts of different dates, the last being March 2, have provided for two places as Astronomers, three as Adjunct Astronomers and three of Astronomical pupils. The following is the present composition of the Observatory personnel.

Director—M. Le Verrier.

Astronomers—M. Faye, M. Yvon-Villarceau.

Adjunct Astronomers—M. Babinet, M. Emile Goujon, M. Chacornac. M. Babinet also is charged with the meteorological observations.

Astronomical Elèves—M. Butillon, M. Reboul, M. Liais. E. B. H.

6. *On manufactured Sea-Water for the Aquarium;* by P. H. Gosse, A.L.S., (Ann. Mag. Nat. Hist., [2], xiv, 65.)—The inconvenience, delay and expense attendant upon the procuring of sea-water, from the coast or from the ocean, I had long ago felt to be a great difficulty in the way of a general adoption of the Marine Aquarium. Even in London it is an awkward and precarious matter; how much more in inland towns and country places, where it must always prove not only

a hindrance, but to the many an insuperable objection. The thought had occurred to me, that, as the constituents of sea-water are known, it might be practicable to manufacture it; since all that seemed necessary was to bring together the salts in proper proportion, and add pure water till the solution was of the proper specific gravity. Several scientific friends to whom I mentioned my thoughts, expressed their doubts of the possibility of the manufacture; and one or two went so far as to say that it had been tried, but that it had been found not to answer; that though it looked like sea-water, tasted, smelt, like the right thing, yet it would not support animal life. Still, I could not help saying, with the lawyers, "If not, why not?"

Experientia docet. I determined to try the matter for myself.

I took Schweitzer's analysis; but as I found that there was some slight difference between his and Laurent's I concluded that a very minute accuracy was not indispensable. Schweitzer gives the following analysis of 1000 grains of sea-water taken off Brighton:

Water,	964·744
Chlorid of sodium,	27·059
Chlorid of magnesium,	3·666
Chlorid of potassium,	0·765
Bromid of magnesium,	0·029
Sulphate of magnesia,	2·295
Sulphate of lime,	1·407
Carbonate of lime,	0·033
	999·998

The bromid of magnesium and the carbonate of lime I thought I might neglect, from the minuteness of their quantities; as also because the former was not found at all by M. Laurent in the water of the Mediterranean; and the latter might be found in sufficient abundance in the fragments of shell, coral, and calcareous algæ, thrown in to make the bottom of the aquarium. The sulphate of lime (plaster of Paris) also I ventured to eliminate, on account of its extreme insolubility, and because M. Laurent finds it in excessively minute quantity. The component salts were then reduced to four, which I used in the following quantities:

Common table salt,	$3\frac{1}{2}$ ounces.	
Epsom salts,	$\frac{1}{4}$ "	
Chlorid of magnesium,	200 grains	Troy.
Chlorid of potassium,	40 "	Troy.

To these salts, thrown into a jar, a little less than four quarts of water (New River) were added, so that the solution was of that density that a specifiic gravity bubble 1026 would just sink in it.

The cost of the substances was—sulph. mag. 1*d.*; chlor. mag. 3*d.*; chlor. pot. $1\frac{1}{2}$*d.*; salt, nil;—total, $5\frac{1}{2}$*d.* per gallon. Of course if a larger quantity were made, the cost of the materials would be diminished, so that we may set down 5*d.* per gallon as the maximum cost of sea-water thus made. The trouble is nothing, and no professional skill is requisite.

My manufacture was made on the 21st of April. The following day I poured off about half of the quantity made (filtering it through

a sponge in a glass funnel) into a confectioner's show-glass. I put in a bottom of small shore-pebbles, well washed in fresh water, and one or two fragments of stone with fronds of green sea-weed *(Ulva latissima)* growing thereon. I would not at once venture upon the admission of animals, as I wished the water to be first somewhat impregnated with the scattered spores of the *Ulva;* and I thought that if any subtle elements were thrown off from growing vegetables, the water should have the advantage of it, before the entrance of animal life. This too is the order of nature; plants first; then animals.

A coating of the green spores was soon deposited on the sides of the glass, and bubbles of oxygen were copiously thrown off every day under the excitement of the sun's light. After a week therefore I venured to put in animals as follows:

2 *Actinia mesembryanthemum.*	*Coryne ramosa.*
7 *Serpula triquetra.*	*Crisia eburnea.*
3 *Balanus balanoides.*	——— *aculeata.*
2 *Sabella* —— ?	*Cellepora pumicosa.*
2 *Sabellaria (alveolata?)*	*Cellularia ciliata.*
2 *Spio vulgaris.*	*Bowerbankia imbricata.*
1 *Cynthia (quadrangularis?)*	*Pedicellina Belgica.*

These throve and flourished from day to day, manifesting the highest health and vigor; the plants (including one or two Red Weeds that were introduced with the animals) looked well, and the water continued brilliantly crystalline. Within the succeeding month specimens of *Actinia mesembryanthemum*, *A. anguicoma* and *A. clavata*, a *Trochus umbilicatus*, and a *Littorina littorea* were at different times added.

Six weeks have now elapsed since the introduction of the animals. I have just carefully searched over the jar, as well as I could do it without disturbing the contents. I find every one of the species and specimens mentioned above, all in high health; with the exception of some of the Polyzoa, viz. *Crisia aculeata*, *Cellepora pumicosa*, *Cellularia ciliata*, and *Pedicellina Belgica.* These I cannot find, and I therefore conclude that they have died out; though if I chose to disturb the stones and weeds, I might possibly detect them. These trifling defalcations do in no wise interfere with the conclusion, that the experiment of manufacturing sea-water for the Aquarium has been perfectly successful. [Lime is important to many animals and had better be added.]

7. *Observations, economical and sanatory, on the employment of Chemical Light for artificial Illumination;* by Dr. E. FRANKLAND, F.C.S., (Proc. Roy. Inst. of Gr. Britain, 1853, 319.)—There are two principal sources of artificial light, viz., electricity and the chemical force; the latter, however, has been, and still is, the only practical source of all artificial light. Although light can be thus obtained by the chemical action of substances belonging to all three kingdoms, yet closer observation demonstrates that the illuminating effect obtained from animal and mineral bodies is primarily derived from the vegetable kingdom; every plant being an apparatus for the absorption and concentration of light and heat from the solar rays, and for the retention of these forces during its passage through the subsequent stages in the formation of vegetable fuel.

Until the commencement of the present century artificial light was derived almost exclusively from the animal kingdom; but the great economy attending its immediate production from our vast stores of vegetable fuel is becoming more and more apparent, and is in fact so generally admitted, as to render more than a mere allusion to it and a glance at the following Table, unnecessary.

TABLE—showing the comparative cost of light from various sources, each equal to 20 sperm candles burning 120 grains per hour each, for 10 hours.

	s.	*d.*
Wax,	7	2½
Spermaceti,	6	8
Tallow	2	8
Sperm oil (Carcel's Lamp),	1	10
London gases, B, C, D, E,*	0	4¼
Manchester gas,	0	3
London gas, A,	0	2¼

We will therefore confine our attention principally to the light produced from vegetable fuel, in considering the economical and sanatory bearings of artificial light.

The production of artificial light depends upon the fact, that at certain high temperatures all matter becomes luminous. The higher the temperature the greater is the intensity of the light emitted. The heat required to render matter luminous in its three states of aggregation, differs greatly. Thus, solids are sometimes luminous at comparatively low temperatures, as phosphorus and phosphoric acids. (A jet of flame produced by the formation of these substances was exhibited, and its temperature shown to be inadequate to the ignition or even scorching of the finest cambric or gun cotton.) Usually, however, solids require a temperature of 600° or 700° F. to render them luminous in the dark, and must be heated to 1000° F. before their luminosity becomes visible in daylight. Liquids require about the same temperature. But to render gases luminous, they must be exposed to an immensely higher temperature; even the intense heat generated by the oxy-hydrogen blowpipe scarcely suffices to render the aqueous vapor produced visibly luminous, although solids, such as lime, emit light of the most dazzling splendor when they are heated in this flame. Hence, those gases and vapors only can illuminate, which produce or deposit solid or liquid matter during their combustion. This dependence of light upon the production of solid matter is strikingly seen in the case of phosphorus, which when burnt in chlorine produces a light scarcely visible; but when consumed in air or oxygen, emits light of intense brilliancy: in the former case the *vapor* of chlorid of phosphorus is produced, in the latter *solid* phosphoric acid.

Several gases and vapors possess this property of depositing solid matter during combustion, but a few of the combinations of carbon and hydrogen are the only ones capable of practical application: these latter compounds evolve during combustion only the same products as those

* London gases, A, B, C, D, E.—These are the gases furnished to consumers by five of the principal London Companies. For obvious reasons the names of the Companies are not mentioned.

generated in the respiratory process of animals, viz. carbonic acid and water. The solid particles of carbon which they deposit in the interior of the flame, and which are the source of light, are entirely consumed on arriving at its outer boundary; their use as sources of artificial light under proper regulations is therefore quite compatible with the most stringent sanatory rules.

In the usual process of gas manufacture there are generated in addition to these illuminating hydrocarbons two other classes of gaseous constituents, viz. impurities and diluents. With the exception of bisulphuret of carbon and some organic compounds containing sulphur, all the impurities are removed in the usual processes of purification, which have now been brought to great perfection; but the presence of these sulphur compounds in coal gas is very objectionable, and constitutes the chief barrier to the universal employment of gas in dwelling-houses. The attention of the manufacturer ought therefore now to be earnestly directed to the discovery of means for preventing the formation of these compounds, as it will probably be found impossible to remove them from the gas when once they have been formed.

In addition to traces of these sulphur compounds, purified coal gas contains only the following ingredients:

		Formula.
Illuminating constituents.	Olefiant gas,	C_2H_2
	Propylene?	C_3H_3
	Butylene?	C_4H_4
	Other hydrocarbons,	unknown.
Diluents.	Light carburetted hydrogen,	CH_2*
	Hydrogen,	H
	Carbonic oxyd,	CO

The light emitted during the combustion of coal gas is due entirely to the first or illuminating class of constituents, which yield an amount of light proportional to the quantity of carbon contained in a given volume; thus, propylene and butylene yield respectively 50 and 100 per cent. more light than olefiant gas, because they contain respectively 50 and 100 per cent. more carbon in a given volume.

It would not be desirable to employ a gas containing only luminiferous ingredients, even if it were possible to manufacture such a gas, because it is exceedingly difficult to consume these constituents without the production of smoke attendant on imperfect combustion. A diluting material is therefore necessary to give the flame a sufficient volume, so as to separate the particles of carbon farther asunder, and thus diminish the risk of their imperfect combustion.

All the three diluents above mentioned perform this office equally well; but if we study their behavior during combustion we shall find that in a sanatory point of view, hydrogen is greatly to be preferred.

The two objections most frequently urged against the use of gas in apartments are, first the heat which it communicates to the atmosphere, and, second, the deterioration of the air by the production of carbonic

* This gas has usually been described as possessing a certain amount of illuminating power, but a specimen of it brought from the coal strata beneath Chat Moss, Lancashire, showed that it yields no more light than hydrogen or carbonic oxyd when consumed from a *fish-tail* burner.

acid. Now, in their action upon the atmosphere in which they are consumed, the above three diluents present striking differences in these two respects.

One cubic foot of light carburetted hydrogen, at 60° F. and 30 in. barometrical pressure, consumes two cubic feet of oxygen during its combustion, and generates one cubic foot of carbonic acid, yielding a quantity of heat capable of heating 5 lbs. 14 oz. of water from 32° to 212°, or causing a rise of temperature from 60° to 80°·8 in a room containing 2,500 cubic feet of air.

One cubic foot of carbonic oxyd at the same temperature and pressure, consumes during combustion ½ a cubic foot of oxygen, generates one cubic foot of carbonic acid, and affords heat capable of raising the temperature of 1 lb. 14 oz. of water from 60° to 66°·6.

One cubic foot of hydrogen, at the same temperature and pressure, consumes ½ a cubic foot of oxygen, generates no carbonic acid, and yields heat capable of raising the temperature of 1 lb. 13 oz. of water from 32° to 212°, or that of 2,500 cubic feet of air from 60° to 66°·4.

This comparison shows the great advantage which hydrogen possesses over the other diluents, especially over light carburetted hydrogen, which is evidently a very objectionable constituent, and shows that a normal gas for illuminating purposes should consist of illuminating hydrocarbons diluted with pure hydrogen. No method is known by which a gas of exactly this composition can be manufactured, but a very close approximation has been lately made to this normal gas, by the employment of a process known as White's Hydrocarbon method of gas-making. In this process the very ingenious principle is adopted of generating the illuminating constituents in as concentrated a form as possible in one retort, and the diluents consisting principally of hydrogen free from light carburetted hydrogen in another. By this arrangement the diluents can be employed for a very remarkable and highly interesting purpose; they are conducted through the retort in which the illuminating constituents are being generated, in such a manner as rapidly to sweep out those constituents, before they have time to become decomposed by contact with the red hot interior surfaces of the retort, a mode of destruction which occurs so largely in the usual process of gas-making. This mode of treatment produces a gain in the amount of illuminating power derived from a given weight of coal, equal to from 50 to upwards of 100 per cent., whilst the increase in quantity of gas is frequently 300 per cent.

The gas thus manufactured differs principally from coal-gas made by the ordinary process, in having a large portion of the light carburetted hydrogen replaced by hydrogen; it is therefore in a sanatory point of view the best gas hitherto produced. This is seen in the following Table, which exhibits the amount of carbonic acid and heat generated per hour by various sources of light, each equal to 20 sperm candles burning at the rate of 120 grains of sperm per hour.

	Carbonic acid.	Heat.
Tallow,	10·1 cubic feet	100
Wax, Spermaceti,	8·3 " "	82
Sperm oil (Carcel's Lamp),	6·4 " "	63
London gases, B, C, D, E,	5·0 " "	47

	Carbonic acid.	Heat.
Manchester gas, - -	4·0 cubic feet	32
London gas, A, - -	3·0 " "	22
Boghead hydrocarbon gas,	2·6 " "	19
Lesmahago hydrocarbon gas,	2·5 " "	19

Notwithstanding the great economy and convenience attending the use of gas, and in a sanatory point of view, the high position which, as an illuminating agent, coal-gas of proper composition occupies, its use in dwelling houses is still extensively objected to. The objections are partly well founded and partly groundless. As is evident from the foregoing table, even the worst London gases produce, for a given amount of light, less carbonic acid and heat than either lamps or candles. But then, where gas is used, the consumer is never satisfied with a light equal in brilliancy only to that of lamps or candles, and consequently, when three or four times the amount of light is produced from a gas of bad composition, the heat and atmospheric deterioration greatly exceed the corresponding effects produced by the other means of illumination. By using a gas however of nearly the normal composition, such as the hydrocarbon gases above named, it is evident that three or four times the light may be employed, with the production of no greater heat or atmospheric deterioration, than that caused by wax candles or the best constructed oil lamps.

But there is nevertheless a real objection to the employment of gas-light in apartments, founded upon the production of sulphurous acid during its combustion: this sulphurous acid is derived from bisulphuret of carbon, and the organic sulphur compounds, which have already been referred to as incapable of removal from the gas by the present methods of purification.

The formation of sulphurous acid can readily be proved and even its amount estimated, by passing the products of combustion of a jet of gas through a small Liebig's condenser; the condensed product being heated to boiling with the addition of a few drops of nitric acid, and then treated with solution of chlorid of barium, yields a white precipitate of sulphate of baryta, if any sulphur compound be present in the gas.

These impurities, which are encountered in almost all coal-gas now used, are the principal if not the only source of the unpleasant symptoms experienced by many sensitive persons, in rooms lighted with gas. It is also owing to the sulphurous acid generated during the combustion of these impurities, that the use of gas is found to injure the bindings of books, and impair or destroy the delicate colors of tapestry. Therefore the production of gas free from these noxious sulphur compounds is at the present moment a problem of the highest importance to the gas manufacturer, and one which demands his earnest attention.

As it is nearly impossible for the consumer to procure gas free from these objectionable compounds, the only method of obviating their unpleasant and noxious effects is to remove entirely the products of combustion from the apartments in which the gas is consumed, and thus prevent them from mingling with the circumambient air. This suggestion was first made by Faraday, who, for accomplishing this object, contrived the very beautiful and effective ventilating burner exhibited in operation upon the lecture table. This apparatus, which is used at Buckingham Palace, Windsor Castle, the House of Peers, and in many

public buildings, may be truly said to have brought gas illumination to perfection; for not only are all the products of combustion conveyed at once into the open air, but nearly the whole of the heat is in like manner prevented from communicating itself to the atmosphere of the room. The only obstacles to the universal adoption of this description of burner are its expense, and the difficulty of conveying the ventilating tube safely into the nearest flue without injuring the architectural appearance of the room. The public at large will therefore still await the removal of the objectionable compounds in question, by the gas manufacturer, before they will universally adopt this otherwise delightful means of artificial illumination. E. F.

8. *Mechanical Action of Heat*; by F. A. P. Barnard.—*Prof. Dana*:—An apology is perhaps due from me to Mr. Rankine, for attributing exclusively to another, in my article on "Heated Air," sent you in November last, but published in March, a formula of thermo-dynamics which was first certainly presented by him in its most complete form, and which is as beautiful for its simplicity as it is practically useful. It may explain if not excuse my inadvertance, to remark that I but followed Mr. Joule in this respect, whose article on the "Economical Production of Mechanical Effect from Chemical Forces," republished from the Memoirs of the Lit. and Phil. Soc. of Manchester in the Lond. Edin. and Dublin Phil. Mag., for Jan. 1853, was necessarily referred to in the preparation of mine; and had been commented upon by Mr. Rankine himself in a letter to Mr. Joule, without his having noticed the error. Not having access to a complete series of the Transactions of the R. S. of Edinburgh, I had been obliged to send abroad for the volume containing Mr. Rankine's original paper, and had not received it, when my article was forwarded to you. Prof. Thompson's paper I had however read in the Lond., Edin. and Dublin Phil. Mag. for July, August and September, 1852; and also his demonstration of the formula in question in the Lond. Phil. Trans., Part I, of the same year. In the paper first mentioned, the formula is not only deducible from the expression cited by Mr. Rankine in the last number of this Journal,* viz.,

$$\frac{W}{H}=1-\epsilon^{-\frac{1}{J}\int_{\tau_{\prime}}^{\tau''}\mu d\tau};$$

but it is actually *deduced*, by combining with the foregoing Mr. Joule's suggestion that "Carnot's Function" may vary inversely as the absolute temperatures, in expression (12) of the same article; which is, when W and H are taken as above to represent the total motive power gained, and the mechanical equivalent of the total heat expended, severally,

$$\frac{W}{H}=\frac{S-T}{\frac{1}{E}+S};$$

where S and T are the thermometric temperatures of the source of heat and of the refrigerator respectively, and E is the reciprocal of the number of degrees between the absolute and the thermometric zero. It is evident that this, when the symbols employed by me to denote

* There is a typographical error in this expression as given in the last number of this Journal.

absolute temperatures are substituted, becomes

$$\frac{W}{H}=\frac{\tau''-\tau_{\prime}}{\tau''}$$

which is the formula ascribed by me to Prof. Thompson.

A foot note, however, by the writer of the paper, had I sufficiently attended to it, would have informed me that Mr. Rankine was independently in possession of substantially the same formula as early if not earlier; for Prof. Thompson remarks that Mr. Rankine has communicated to him a formula for the ratio of power obtained to the mechanical equivalent of the heat expended, which agrees exactly with his own.

It may be remarked also, that Mr. Rankine had published his formula in the Lond. and Edin. Phil. Mag. as early as July, 1851, in a note to his letter to Poggendorff; and had reproduced it in the same journal in February and in June, 1853; so that I could hardly be unaware that he had independently originated it.

I am happy, in making this correction, to express my admiration of the ingenious theory suggested and so ably developed by Mr. Rankine, to account for the mechanical phenomena of heat. I regard the coincidence of the results deduced from premises so different as those employed by himself and Prof. Thompson, as one of the most beautiful examples of the consistency of truth which the history of science furnishes.

The necessity of a negative constant, represented by κ in the denominator of the formula as given by Mr. Rankine, for temperatures determined by the air thermometer, was pointed out by him alone. This constant, which becomes zero on supposition of the rigorous conformity of elastic fluid, at all temperatures, to "the gaseous laws," and which is always small, was neglected by me, partly because I took the formula directly from Prof. Thompson (Lond. Phil. Trans., Part I, 1852), and partly because Mr. Rankine had shown it to be too inconsiderable to be important to the purpose I had in hand.

Univ. of Alabama, July 7, 1854.

9. *Siluria, The History of the Oldest Known Rocks containing Organic Remains, with a brief sketch of the Distribution of Gold over the Earth;* by Sir R. I. Murchison, G. C. St. S., &c. &c. 524 pp. 8vo, with 37 plates of fossils. London, 1854. J. Murray.—A work of great value and interest.

10. *Elementary Chemistry, Theoretical and Practical;* by George Fownes, F.R.S., late Professor of Practical Chemistry in University College, London. Edited with additions by Robert Bridges, M.D., Prof. Chem. Philad. Coll. of Pharmacy, etc. A new American from the last London edition, with numerous illustrations on wood. 555 pp. 12mo. Philadelphia, 1853. Blanchard & Lea.—This is a most excellent text-book for class instruction in chemistry, whether for schools or colleges. The death of Mr. Fownes left the recent revision of the work to the able chemists, H. Bence Jones and A. W. Hofmann of London, under whose auspices the last (4th) London edition was prepared for the press.

11. *Manual of Natural History for the use of Travellers*, being a Description of the Families of the Animal and Vegetable Kingdoms, with Remarks on the Practical Study of Geology and Meteorology; to which are appended Directions for collecting and preserving. By Ar-

THUR ADAMS, M.R.C.S., F.L.S., &c., WILLIAM DALFOUR BAILIE, M.D., F.R.S.E., and CHARLES BARRON, Curator of the Royal Naval Museum at Haslar. 750 pp. 16mo. London, 1854. John Van Voorst.

12. *The Microscope and its application to Chemical Medicine;* by LOVELL BEALE, M.B. London, Prof. of Physiology and General and Morbid Anatomy in King's College, London. 302 pp. 12mo. *London*, 1854. Samuel Highley.—The value of the microscope to the medical man is beginning to be understood and appreciated. The Treatise of Prof. Beale is well calculated to instruct the student in the use of the instrument and in the methods of dissecting, preparing, and examining objects that may be of interest to him. After earlier elementary information, a chapter is devoted to the injecting of preparations; another to the modes of preparing tissues, the kidney, liver, &c.; others to examinations of the brain, nerves, nervous and serous membranes, morbid growths, etc, etc. The details are full and have special reference to the necessities of the medical man. The work is illustrated with a plate of crystalline substances, and numerous fine wood-cuts, among which are two large views of microscopes, and figures of the various tissues, cells, morbid growths or deposits, etc., described in the text.

We observe that in the remarks on the application of a goniometer to the microscope, it states that "the simplest method of measuring the angles of microscopic crystals is that of Schmidt." This Mr. Schmidt, is Prof. J. Lawrence Smith, late of the Virginia University, and now of the Louisville Medical School.

13. *Report on the Geology of the Coast Mountains and part of the Sierra Nevada*, embracing their industrial resources in Agriculture and Mining; by Dr. JOHN B. TRASK. Assembly Doc., No. 9. San Francisco, 1854.—A pamphlet of 96 pages, and not a result of a careful survey.

14. *Natural History Review.* Dublin, April, 1854. 104 pp. 8vo.—This new quarterly is announced to appear on the 1st of January, April, July and October. The April Number contains Reviews of works on Science, with notices of the contents of some prominent scientific periodicals in Zoology and Botany, and the Proceedings of Irish scientific societies. It promises to be a valuable work.

15. *Bibliographical Notices by M. Jerome Nicklès.*

Methode de Chimie par A. LAURENT, avec une notice par M. BIOT. 1 vol. in 8° de 460 pages. Paris, chez Mallet-Bachelier.

Théorie Générale des effets dynamiques de la Chaleur, par F. REECH, Ingenieur de la Marine, Directeur de l'école d'application du génie maritime.—S. Carnot published in 1824, a work entitled "*Reflexions sur la puissance motrice du feu.*" It contained some remarkable views on the manner of producing motive power with heat. The reasoning of Carnot was subjected by M. Clapeyron to mathematical analysis; both calculations and reasoning being founded on the absurdity of admitting the possibility of *creating* motive force or heat. The recent discoveries having deprived us of one of the properties considered fundamental by these authors, some writers, as Joule, Thompson, Rankine, Mayer and Clausius have applied themselves to the fuller investigation of what appeared inaccurate in the relations established by Carnot and Clapeyron.

Persuaded that in all these researches too much importance had been given to hypotheses, the logical train of reasoning of Carnot being lost

sight of, M. Reech has made the subject complete from a new point of view, establishing a formula in harmony alike with the results of M. Joule and those of M. Regnault. The work of M. Reech has excited much attention among mechanicians, and it will be studied with interest by all who are occupied with the mechanical properties of steam, warm air, etc. The volume is a quarto of 212 pages, published by Mallet-Bachelier, Paris.

The following works have also appeared at the same house:

Précis des œuvres mathematiques de Fermat et de l'arithmetique de Diophante par Brassine, Prof. à l'école d'artillerie de Toulouse. 1 vol. 8vo.—P. Fermat, inventor of the infinitesimal calculus, founder of the theory of numbers, published his collected memoirs in 1679. These remarkable works having become very rare, government made in 1843 an appropriation for their reprint; this project never having been carried out, M. Brassine has collected the principal works of Fermat, and added the correspondence between Fermat, Pascal, Digby, etc. The volume includes the statements of the propositions which enter into the six books of Diophantus, with the observations of Fermat which are very rich in fine theorems. This portion presents to teachers an excellent collection of arithmetical problems.

—— *Traité du calcul differentiel par l'abbé* Latrent. 1 vol. 8vo.—This valued work is indispensable to all who are studying the higher mathematics. It serves as an introduction to the treatises of Cauchy, Moigno, and especially the—

—— *Traité de mecanique par* M. Duhamel. 1 vol. in 8vo.—M. Duhamel, member of the French Institute, has been for a long time director of the studies of the Polytechnic School, where he still holds the professorship of mechanics with unquestioned ability. His treatise has been very successful among Professors, Engineers, the officers of artillery, and others.

—— *Uranographie ou Traité élémentaire d'astronomie par* Francœur. 1 vol. in 8vo. 6th edition.—This edition is posthumous, and is published by the son of M. Francœur. The father who was known among scientific men by his vast and varied attainments, was distinguished before the public for his rare talent in exposition. The Uranography partakes of this happy quality. Without requiring other calculations than those of arithmetic, and the elements of geometry, Francœur initiates the reader into the most delicate questions of astronomy, and even sets him to resolving important problems. The author has also in view the instruction of men of letters. Knowing that poets and orators of ancient time were well instructed in Astronomy, Physics, &c., he wished that our modern writers should be equally well taught in science, that they might not absurdly employ themselves with ideas suggested to them, which they did not understand, or like certain lawyers plead for a patent right on some chemical matter which they knew as little of as the judges. The first two parts of the book might be read with profit by all; the third part contains calculations, and is addressed to the learned in the science.

—— *Leçons de Cosmographie par* MM. Harant et Lafitte. 1 vol. in 8vo. of 188 pages.—This work has a less general end; it has been got up in view of the new programme of instruction which the government has imposed upon Colleges, Lyceums, and on candidates for ad-

mission to the polytechnic and naval schools, and the school of arts and manufactures. In spite of the narrowing restrictions, the authors have succeeded in giving a truthful sketch of history, and at the same time in delineating the successive developments of the human mind. The clear and methodical expositions which characterize the work, render it valuable to students and even to professors.

—— *Chimie photographique par* MM. BARRESWILL et DAVANNA. 1 vol. in 8vo, 287 pages.—The authors give the theory of photographic manipulations, the photographic processes on metallic plates, on paper dry and moist, upon glass prepared with collodion and with albumen; the manner of preparing the same; of employing the reagents, and of making the residues useful; the newest and most perfect methods; and finally they treat of engraving and lithography. With the aid of this book, the photographer, though little acquainted with chemistry, is enabled to purchase safely, and to employ judiciously, the best materials.

—— *Recherches cliniques sur les Eaux-Bonnes par* E. CAZENAVE. Pamphlet in 8vo. of 100 pages.—The author who is a physician at Eaux-Bonnes (Pyrenees) reports his observations and the results of his investigations on the diseases which belong to the vicinity of those waters. This work is especially interesting to physicians and naturalists.

—— *Des mesures propres à prévenir les collisions sur les chemins de fer, par* M. COUCHE, professeur a l'ecole des Mines de Paris, Pamphlet in 8vo, 48 pages. Paris, chez Carillan-Goeury.

—— *Des accidents sur les chemins de fer par* E. WITH. Pamphlet in 12mo. of 148 pages. Paris, Mallet-Bachelier.—These two pamphlets have been called out by the numerous railroad accidents which have occurred in France during the last year. The authors discuss with much ability the different methods that may be employed to prevent such accidents. M. Couche is chief engineer of a prominent railroad, and therefore well situated to judge of these things; this is true also of M. With.

—— *Stenarithmie ou Abréviation des calculs par* GOSSART, 1 vol. in 12 de 120 pages. Paris, Mallet-Bachelier.

—— *Problème de Mathématiques et de Physique par* DUVIGNAU. 1 vol. in 12 de 140 pages. Paris, Mallet-Bachelier.

—— *Arithmétique a l'usage des instituteurs par Finance*, 1 vol. in 12 de 236 pages. Paris, chez Mallet-Bachelier.

PROCEEDINGS OF THE ACAD. OF NAT. SCI. OF PHILADELPHIA. Vol. VII. No. 3.—p. 72. Bones of Saurians from near Greenville, Clarke Co., Arkansas (Brimosaurus grandis, L., Cimoliasaurus magnus, L., with a plate); *J. Leidy.*—p. 73. Synopsis of the Cucuiides of the United States; *J. L. Le Conte.*—p. 79. Notice of some Coleopterous Insects from the Collections of the Mexican Boundary Commission; *J. L. Le Conte.*—p. 85. Notice of a new species of Salamandra from the Northeastern part of the United States; *C. Girard.*—p. 86. A list of the North American Bufonids, with Diagnoses of new species; *C. Girard.*—p. 89. A bone referred to Sus Americanus by Harlan and named Harlanus by Owen, who made it a tapiroid pachyderm, shown by *Leidy* to belong to a ruminant, and this the *Bison latifrons.*—p. 90. On fossils from South Carolina and Nebraska; *J. Leidy.*—p. 91. Descriptions of new Reptiles from California; *E. Hallowell.*—p. 97. On a genus and species of Serpent from Honduras, pronounced to be new; *E. Hallowell.*—p. 98. On the Geographical Distribution of Reptiles, with descriptions of several species supposed to be new, and corrections of former papers; *E. Hallowell.*—p. 105. Descriptions of four new species of Viviparous Fishes from Sacramento River, and the Bay of San Francisco; *W. P. Gibbons.*—p. 106. Synopsis of the Dermestidæ of the United States; *J. L. Le Conte.*—p. 113. Synopsis of the Byrrhidæ; *J. L. Le Conte.*—p. 118. Descriptions of new Birds collected between Albuquerque, N. M., and San Francisco, California, by Dr. C. B. R. Kennerly and H. B. Möllhausen; *S. F. Baird.*

ble to pursue the mode which ...

* Throughout this paper the whole difference of the A. M. and P. M. tides is taken as the diurnal inequality.

...scriptions of four new species

...ver, and the Bay of San Francisco; *W. P.*

106. Synopsis of the Dermestidæ of the United States; *J. L. Le Conte.*

...nopsis of the Byrrhidæ; *J. L. Le Conte.*—p. 118. Descriptions of new

...d between Albuquerque, N. M., and San Francisco, California, by Dr.

...nnerly and H. B. Mollhausen; *S. F. Baird.*

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXIII.—*On the Tides at Key West, Florida, from observations made in connexion with the United States Coast Survey;* by A. D. Bache, *Superintendent.*—Communicated by authority of the Treasury Department; revised from the Proceedings of the American Association for the Advancement of Science. (With six Plates.)

Hourly observations of the tides were made at Fort Taylor, Key West, from the 1st of June, 1851, to the 31st of May, 1852, by Mr. J. W. Goss, of the Coast Survey and assistants. The tides ebb and flow twice in the twenty-four hours, but the diurnal inequality in height is relatively large, amounting at a mean to 0·55 foot, and reaching, in extreme cases, 0·83 foot.* The mean rise and fall of the tide being about 1·4 foot, a knowledge of the laws of the diurnal inequality by which successive high or low waters may differ is very important. The corrected establishment of Key West is 9h. 22m. The curves of Plates 1, 1 bis, 1 tris, 2, 3, 4, and 5, show the normal character of the tides at the maximum and zero of the moon's declination at the syzigies and quadratures, and at a mean of declination and six hours of the moon's age. There being two tides in the lunar day, the observations admit of discussion by the ordinary methods, while the large diurnal inequality in height of high water renders it desirable to pursue the mode which I have applied to the tides at Cat

* Throughout this paper the whole difference of the A. M. and P. M. tides is taken as the diurnal inequality.

Island (Louisiana), and Fort Morgan (Alabama.) The reductions by the ordinary methods thus become the tests of those by the other mode. The former were made under my immediate direction by Lieut. Richard Wainwright, U.S.N., and Mr. M. H. Ober, U. S. Coast Survey, and the latter by Mr. W. W. Gordon, assisted by Messrs. Mitchell, Homans, and others, of the Coast Survey.

The *half-monthly inequality* in time and height as deduced by the usual method is shown in the following Table No. 1, in which the first column contains the moon's age, the second the mean lunitidal interval corresponding, and the fifth the height.

TABLE No. 1.

Half-monthly inequality of tides at Key West from one year's observations.

Moon's age.	Interval.			Height.		
1.	O. 2.	T. 3.	O—T. 4.	O. 5.	T. 6.	O—T. 7.
H. M.	H. M.	H. M.	M.	feet.	feet.	feet.
0 30	9 21	9 21	00	6·34	6·34	0·00
1 30	9 05	9 07	02	6·31	6·32	·01
2 30	8 51	8 54	03	6·25	6·26	·01
3 30	8 47	8 46	01	6·17	6·16	·01
4 30	8 50	8 55	05	6·08	6·06	·02
5 30	8 54	8 58	04	6·00	5·97	·03
6 30	9 22	9 25	03	5·94	5·94	·00
7 30	9 52	9 49	03	6·00	5·98	·02
8 30	9 59	10 00	01	6·02	6·08	·06
9 30	9 59	9 58	01	6·12	6·18	·06
10 30	9 53	9 58	05	6·22	6·27	·05
11 30	9 35	9 35	00	6·30	6·33	·03
	9 22					

The mean interval for this table is 9h. 22m., corresponding to the epoch of the moon's age of 24 minutes, showing that the transit E (of Mr. Lubbock's notation) and not F should be used in the reduction for theoretical purposes.

The comparison between the results of observation and those from the formula for the half-monthly inequality is shown in the fourth and seventh columns, the fourth referring to the interval and the seventh to the height. The difference in the mean is inappreciable, and, at a maximum, is but five minutes of interval, and six hundredths of a foot of height.

A graphic comparison is made on Plate 2. The value of the constant (A) of the formula for the interval, $\tan 2\psi = \frac{(A)\sin 2\varphi}{1+(A)\cos 2\varphi}$ is 0·325, and of E in the formula for the height $h = D + E[(A)\cos(2\psi - 2\varphi) + \cos 2\psi]$ is 0·620.

The values of the *diurnal inequality* of high and low water, both in time and height, were obtained by comparing the mean value of the interval and height for the first and second six months, with the individual values; they followed closely the law of change with the moon's declination. The inequality in height of high water at a mean is to that of low water as 79 to 61.

As the observations were only made hourly, and the inequality in the interval of high water is small, the minute changes from day to day could not be expected to show themselves. The inequalities were grouped according to the different declinations of the moon into fourteen periods, and the approximate formula, given by Mr. Lubbock, for the variation from the mean, was applied. The agreement with theory, as shown in the annexed table, is very close; G was taken as 1·15.

TABLE No. 2.

Comparison of the diurnal inequality of high water at Key West, with the formula

$$d\psi = \frac{G \tan \delta'}{1 + (A)\cos 2\varphi}.$$

Moon's declination.	Diurnal inequality.		Difference.
	Observed.	Computed.	
° ′	Minutes.	Minutes.	Minutes.
3 55	13	15	— 02
7 15	25	29	— 04
11 30	48	47	01
15 45	61	64	— 03
18 55	74	78	— 04
20 55	88	87	01
21 30	100	91	09
21 55	95	92	03
20 15	84	85	— 01
17 30	83	72	11
13 55	52	56	— 04
9 15	37	38	— 01
5 15	25	21	04
2 55	07	11	— 04
			— 23
			+ 29
			52

The inequalities of time of high water were also arranged according to the moon's age, but the agreement of the observation with the formula is not as close as in the former case, as must be the case from the small number of observations, and the variation of the inequality following chiefly the law of the declination. The law of change is still evident in the grouping, and the plus and minus quantities balance nearly.

The discussion of the diurnal inequality in height will be resumed in referring to the diurnal wave, after noticing the decomposition of the curve of observation into a semi-diurnal and diurnal curve.

Decomposition of the curves of observation.

As in the discussion presented for the Cat island tides, the curves of observation at Key West were decomposed into two—one representing the semi-diurnal and the other the diurnal tide. The interval (E), which was in the former case assumed to be constant, was here treated as variable. The observed ordinates being referred to the mean of high and low water of the day as

a zero, were tabulated, and the maximum ordinates S and D of the semi-diurnal and diurnal curves of sines found, taking (E) generally at its mean value. From these the ordinates of each curve for the several hours were obtained, and thence the ordinates of the compound curves. These were compared with observation, and E was next made to vary until the value was found, which gave the sum of the differences of computation and observation, without regard to sign, the smallest.

It was next intended, treating this as a first approximation, to take a different zero-point for the semi-diurnal curve, but the labor necessary has prevented this idea from being followed up thus far, and the agreement of the computed and observed curves is quite satisfactory in the cases in which E is not varying too rapidly for safe deductions. The labor and uncertainty of deducing E from the observations in the manner just referred to is very considerable, and, after one full comparison made in this way, the values will be deduced from theory, and applied to the curves.

The approximate compound curve was next projected on a diagram of suitable scale, and the outline cut from the paper so as to apply it to the curve of observation, and thus to find its best position in reference to that curve, and to determine the times of high water. The work referred to in the paragraphs preceding the last is mechanical, but this latter requires much judgment, and has been executed by Mr. W. W. Gordon. Supposing that some discrepancies observed might result from a sort of personal equation in making these comparisons, a second person was engaged to repeat them for verification, and the result showed that the comparison could be depended upon in individual cases to within about five minutes in time in the position of the maximum ordinates.

Semi-diurnal Tides.

The times of high water from the semi-diurnal curves being taken from the diagrams, are subject to an error, which Mr. Gordon estimates as from four to five minutes. This, however, does not appear in the final results, which agree as well with theory as those for the heights, not subject to any such error of estimate.

The lunitidal intervals and heights found were tabulated according to the moon's age, as in the following tables, which contain the result for the first and second six months of the year and for the whole year. The fourth and seventh columns contain, respectively, the differences in the interval and height drawn from the curves, and from the formula for the half-monthly inequality referred to in the previous part of this paper:

TABLE No. 3.—*First six months.*

Moon's age.	Interval.			Height.		
	O.	C.	Difference. O—C.	O.	C.	Difference. O—C.
H. M.	H. M.	H. M.	M.	feet.	feet.	feet.
0 30	8 53	8 54	1	0·75	0·75	0·00
1 30	8 38	8 42	4	·73	·72	·01
2 30	8 29	8 30	1	·64	·66	·02
3 30	8 24	8 24	0	·60	·58	·02
4 30	8 28	8 27	1	·48	·49	·01
5 30	8 42	8 40	2	·45	·43	·02
6 30	9 06	9 03	3	·42	·42	·00
7 30	9 23	9 23	0	·44	·46	·02
8 30	9 31	9 30	1	·53	·54	·01
9 30	9 28	9 28	0	·61	·62	·01
10 30	9 20	9 19	1	·68	·69	·01
11 30	9 09	9 07	2	·75	·74	·01
	8 57					

TABLE No. 4.—*Second six months.*

Moon's age.	Interval.			Height.		
	O.	C.	O—C.	O.	C.	O—C.
H. M.	H. M.	H. M.	M.	feet	feet.	feet.
0 30	8 53	8 52	1	0·78	0·77	0·01
1 30	8 42	8 39	3	·72	·75	·03
2 30	8 27	8 28	1	·69	·68	·01
3 30	8 22	8 21	1	·59	·59	·00
4 30	8 22	8 23	1	·49	·49	·00
5 30	8 34	8 38	4	·46	·42	·04
6 30	9 04	9 03	1	·40	·40	·00
7 30	9 22	9 23	1	·44	·45	·01
8 30	9 31	9 31	0	·53	·54	·01
9 30	9 32	9 28	4	·62	·64	·02
10 30	9 20	9 19	1	·69	·72	·03
11 30	9 04	9 06	2	·71	·77	·06
	8 56					

TABLE No. 5.—*The whole year.*

Moon's age.	Interval.			Height.		
	O	C.	O—C.	O.	C.	O—C.
H. M.	H M.	H M.	M.	feet.	feet.	feet.
0 30	8 53	8 53	0	0·76	0·76	0·00
1 30	8 40	8 40	0	·73	·74	·01
2 30	8 28	8 29	1	·67	·67	·00
3 30	8 22	8 22	0	·59	·59	·00
4 30	8 25	8 25	0	·49	·50	·01
5 30	8 38	8 39	1	·45	·43	·02
6 30	9 05	9 03	2	·41	·41	·00
7 30	9 22	9 23	1	·45	·46	·01
8 30	9 31	9 31	0	·53	·54	·01
9 30	9 30	9 28	2	·62	·63	·01
10 30	9 20	9 19	1	·69	·71	·02
11 30	9 06	9 07	1	·73	·75	·02
	8 57					

Curves showing the result of these comparisons are given in Plate 2. The greatest difference for the whole year between the two sets of results is but one minute of time for the interval, and ·02 foot in height.

The results are in apparent time, the substitution of which for mean time was, however, appreciable in but a slight degree.

There are several small corrections suggested by the hypothesis which has been adopted, but the small value of the residuals renders the following of them up unnecessary. To the last computations we have reached no greater accuracy than is presented by these residuals, and could not safely base any conclusions on less quantities.

The ordinates used in the heights are the maximum ordinates of the component curves, and not those of high water of the compound curve; but it is easily shown that when the value of (E,) when most nearly constant, is, as at Key West, between about nine and nine a half hours, this difference is inappreciable.

The solar day having been used in this decomposition instead of the lunar, the curves are at a mean twenty-five minutes behind their true place, and the mean lunitidal interval differs twenty-five minutes from the truth; adding this quantity, it agrees, as it should do, with the former determination.

For the reason just assigned, these numbers would require correction before using them to determine the constants. This, when made, gives the result as before stated.

Diurnal tides.

The maximum ordinates found for the diurnal tides from the decomposition of the curves of observation were grouped according to the declinations of the moon, by magnitude without regard to sign, as shown in the first and second column of Table No. 5.

The maximum ordinates may, in this case, be reduced to high water ordinates by a very simple process, and thus a comparison be established between this mode of reduction and the ordinary one. For (E) = 9h. 30m., the high water ordinate is 0·79, the maximum, provided, as in the case at Key West, the time of high water may be taken as that of the semi-diurnal wave.

The following table shows the moon's declination, the corresponding mean maximum ordinate, twice the high water ordinate deduced from this, (which is the diurnal inequality from our mode of reduction,) the diurnal inequality as usually obtained, and the difference.

TABLE No. 6.

Sine twice moon's declination.	Maximum ordinate	Twice high water ordinate, (C.)	Diurnal inequality, (C').	Difference, (C'—C).
	feet.	feet.	feet.	feet.
11	0·12	0·20	0·19	—·01
21	·17	·27	·28	·01
35	·28	·44	·44	·00
48	·38	·59	·60	·01
59	·46	·71	·70	—·01
66	·51	·80	·79	—·01
69	·54	·84	·83	—·01
Mean		·55	·55	

The results are represented in Plate No. 3.

The statement made above in relation to the high water ordinates is not true for those of low water, as the consideration of the formula $y = C. \cos 2t + D \cos (t - E)$ will show, making $E > 9$ hours. The reverse is the case if $E < 9$ hours, the statement applying then to the inequality of low water and not of high. At Key West, while the high water inequality in height is thus readily found from the maximum ordinate, the low water presents a less accordant result; while at Cedar Keys just the reverse occurs, as should be the case.

It is plain, also, that changes in the coefficients C, D, and in E, will cause the inequalities in times and heights to vary, as well as those of high and low water, losing all correspondence with each other, as is also well shown in the annexed diagram. Mr. Gordon suggests that in the value of (E) will be found the full explanation of the peculiarities of the Petropaulofsk tides described by the Rev. Mr. Whewell.

In diagram No. 1, Plate No. 5, E is assumed 9 hours and $S = D$, and the inequality of high and low water in interval and height correspond to each other. The same is the case for $E = 15$ hours. In No. 2, E is 12 hours, and $S = D$. The inequality in interval of high water is 0h., of low water 4h., when that in height of high water is 2 feet, and of low water 0 feet. For E, 18 hours and $S = D$, these inequalities would be reversed, that of interval of high water being 4h., and of low water 0h., while for height the inequality of high water is 0 feet, and of low water 2 feet.

Using the high water ordinates, determined as before stated, instead of the diurnal inequality in height, from which it has been shown not to differ sensibly, the numbers were compared with those of Mr. Lubbock's formula:

$$dh = B\left[\,(A) \sin 2\,\delta \cos (\psi - \varphi) + \sin 2\delta \cos \psi\right];$$

Neglecting the variations of $\cos (\psi - \varphi)$, $\cos \psi$, the coefficients B and (A) B were found by least squares for the separate six months and for the year, agreeing sensibly in the partial and total determinations. From two years' results, $B = 0{\cdot}56$ and $(A)\,B = 0{\cdot}16$. The value of (A) thus obtained is, as it should be, the same as deduced from the half-monthly inequality.

The sum of the squares of the difference of the numbers from the formula, and from the computed high water ordinates, is for the year but 0·0087 foot; corrected for the moon's parallax, but 0·0078 foot.

The individual results are given in the annexed table, in which the first column contains the moon's age, the second the difference between the computed high water ordinates and the corresponding quantities from the formula for the variations of the

diurnal inequality in height, corrected for parallax, and the third the same, as uncorrected for parallax.

TABLE No. 7.

Moon's age.	Diurnal inequality height; observation—theory.		Moon's age.	Diurnal inequality height; observation—theory.	
	Corrected.	Uncorrected.		Corrected.	Uncorrected.
H. M.			H. M.		
0 30	005	010	6 30	−080	−085
1 30	005	005	7 30	−090	−090
2 30	−035	−030	8 30	−065	−065
3 30	−035	−035	9 30	−020	−020
4 30	−075	−080	10 30	−030	−030
5 30	−070	−070	11 30	+005	010

The residuals are very small, but follow the law of the half-monthly inequality, as was found, also, from the corresponding results of the Cat Island observations.

The discussion of the value of E, which is in progress, I hope to present at a future meeting of the Association.

Changes of mean level.

The mean level of the water at Key West was seen from the observations to undergo remarkable changes from one period of the year to another. A comparison of the reductions for the first and second six months shows that the high water of neap tides of the first period rises actually to a higher level than the high water of spring tides of the second. The mean level of the high water for the first six months exceeds that for the second by 0·48 foot. The form of the half-monthly inequality is perfectly regular in each six months. The guage had remained undisturbed; and in seeking for the explanation, it was observed that the mean level of the water varied very materially in the two periods, there being a change which appeared to go through its variations in the course of the year.

The annexed table shows the heights of high water at the several ages of the moon in the first and second six months, referred to the same zero.

TABLE No. 8.

Moon's age.	Height of high water.	
	First six months	Second six months
H. M.	feet.	feet.
0 30	6·63	6·05
1 30	·59	·04
2 30	·48	·02
3 30	·38	5·97
4 30	·31	·86
5 30	·26	·75
6 30	·17	·72
7 30	·28	·72
8 30	·26	·79
9 30	·34	·90
10 30	·43	6·01
11 30	·54	·06
	6·39	5·91

I hardly supposed that the numbers representing these changes of level would furnish evidence of the two interesting tides of long period pointed out by Mr. Airy, (Tides and Waves, Encyc. Metrop., p. 355;) they do so, however, and in the case of the moon's action, where the number of averages which can be brought to bear upon a single result is considerable, and the observations run through various parts of the year, the results bear carrying to numerical comparison with the formula. These tides, as far as I am aware, have not been developed from observation, though certain general analogies pointed to their existence. Dividing the numbers showing the daily level of the water into groups of nearly fourteen days, each corresponding to the moon's declination from the maximum to the maximum again, and taking the mean of each set corresponding to the same declination, we obtain a series which is the average of twenty-six numbers in which the irregularities of the depressing and elevating action of the winds will be eliminated, and in which the sun's action will be nearly the same. This series presents a tolerable regularity increasing to a maximum at zero of declination, as shown in Plate No. 6, curve No. 1.

Taking the mean level of the water for each fourteen days, and dividing the results into two groups corresponding to the same declination of the sun, north and south, we have a series of numbers which, though less regular than the others, also rise towards the zero of declination, as shown in Plate 6, curve No. 2.

The results of the first series of computations bear very well a comparison with the formula given by Mr. Airy:

$$(1{\cdot}34\times\sin^2\mu+0{\cdot}61\times\sin^2\sigma)(\cos 2\lambda+c,)$$

in which μ and σ are the declinations of the moon and sun respectively, and λ is the latitude of the place, requiring $C=O$. Those of the second present greater discrepancies and require $C=\frac{1}{3}$, contradicting the former. Though the weight of authority is that in favor of the criterion of the wave theory $C=O$, the result is inconclusive. In either case the whole number involved is less than the tenth of a foot, the theoretical lunar tide being 0·095, and the measured 0·098, while the theoretical solar tide for $C=O$ is 0·046, and the measured is 0·077.

It may be necessary to remark that for places of low latitudes the increase of numbers in the formula corresponds to a fall of the tides.

The regularity of the winds of this region, the trade winds, taken in connexion with the form of the harbor, point also to their action as a source of explanation of this change of level. The meteorological tables kept while the tidal observations were made, furnish means for a complete discussion, which is in progress. I may remark, now, that winds tending to elevate the water in the harbor prevail for six months, from March to August inclusive, and those tending to depress it for the other six months, from

September to February inclusive. The subject is one in which it is difficult to come to numerical results, because the variations in the force of the wind and the duration both enter into the effect, and distant action sometimes causes local effects. The whole rise and fall is nearly three-quarters of a foot.

The mean level of the water deduced from the mean of high and low water in each month is shown in the annexed table.

TABLE No. 9.

Month.	Height in feet	Month.	Height in feet
June, - - - -	5·60	December, - - - -	5·31
July, - - - -	·78	January, - - - -	·11
August, - - - -	·63	February, - - - -	·15
September, - - -	·93	March, - - - -	·26
October, - - - -	·90	April, - - - - -	·26
November, - - -	·73	May, - - - - -	·32
	5·76		5·24

Art. XXXIV.—*On the Geographical Distribution of Crustacea;* by James D. Dana.*

In volume xvi, of this Journal, the author presented a chart of oceanic isothermal (or rather isocrymal) lines, for the illustration of marine zoological geography, prepared more especially with reference to the geographical distribution of Crustacea, and taken from his Report on the Crustacea of the Exploring Expedition around the world under Capt. Wilkes. The following is a brief abstract of the remainder of the Chapter on the Distribution of Crustacea; the Tables which occupy near 30 pages are omitted besides other details.

The lines on the chart, it may be here repeated, are lines of equal winter (or coldest month) temperature for the water, the "cold" lines being adopted because the distribution of species away from the Tropics is limited by cold temperature. The temperatures corresponding to the lines are 74°, 68° (limiting temperature of coral reefs), 62°, 56°, 50°, 44°, 35° F. Between the lines of 68° F. north and south of the equator lies the *Torrid Zone* of oceanic water temperature; from the line of 68° to that of 35°, the *Temperate Zone;* beyond the line of 35°, the *Frigid Zone.* These Zones are divided by the lines into Regions or Sub-zones as follows.

I. TORRID ZONE.	1. Torrid Region or Sub-zone,		74° and above.
	2. Subtorrid	"	68° to 74°
II. TEMPERATE ZONE,	1. Warm Temperate	"	62° to 68°
	2. Temperate	"	56° to 62°
	3. Subtemperate	"	50° to 56°
	4. Cold Temperate	"	44° to 50°
	5. Subfrigid	"	35° to 44°
III. FRIGID ZONE.			

* From the Author's Report on Crustacea, (2 vols. 4to, 680 and 1620 pages).

The reader is referred to the former paper and map for other details, where the Zoological Provinces in these zones are laid down, and explained.

The Tables are in two series. The first contains for each genus of Crustacea the number of species *according to present knowledge* in each temperature Region or Sub-zone.* The second, the number for each genus in each *Geographical Province.*

We proceed with a summary of the results presented in the first series of the Tables.

I. BRACHYURA.

	a. Torrid.	*b.* Sub-torrid.	Total of Torrid zone.	*c.* Warm Temperate.	*d.* Temp'ate.	*e.* Sub-temperate.	*f.* Cold Temperate.	*g.* Sub-frigid.	Total of temperate zone.	*h.* Frigid.
Maioidea, - - - -	82	57	122	35	27	21	16	14	92	3 (2)
Cancroidea - - - -	157	112	229	22	25	23	25	8	69	3 (3)
Grapsoidea, - - - -	72	88	131	21	14	27	10	9	63	
Leucosoidea, - - -	35	33	48	11	8	5	3	2	24	
Corystoidea, - - -	2	3	5	2	4	2	6	6	16	1 ?
	348	293	535	91	78	78	60	39	264	

This table contains the number of species of the orders of Brachyura, according to present knowledge, in each Region and Zone.

The following general facts or conclusions may be deduced from the Tables of the Brachyura.

I. The line of division, separating the Torrid and Temperate zones of ocean temperature, following the isocryme of 68° or the outer limit of coral reef seas, marks a grand boundary in organic life, well exemplified in Crustacean species. Out of the five hundred and thirty-five species of the Torrid and Subtorrid Regions (the Torrid zone,) there are over one hundred now known to be common to the two. But of the two hundred and sixty-four in the Temperate Regions, only thirty-four occur in the Torrid zone. A large number of genera, containing more than a single known species, are confined wholly to the Torrid zone: such are Micippa (5 species), Menæthius (9), Huenia (4), Parthenope (3), Atergatis (17), Carpilius (13), all the Chlorodinæ, including forty-nine species, nearly all the Eriphinæ, including eighteen species, Charybdis (15). At the same time, the species of the Torrid and Subtorrid Regions are in many cases equally numerous. Of species of Charybdis, eleven species occur in each of these Regions; of the Carpilii, eleven are reported from the Subtorrid and but five from the Torrid; of the Menæthii, five are found in the Torrid Region, and six in the Subtorrid, only two being common to both. These proportions may be much varied by future in-

* Since the ocean's waters decrease in temperature as we descend in depth, there will be some error in the tables from the cold water species thus passing into regions nearer the equator. But this error will diminish the number of species regarded as peculiar to the colder regions, and if eliminated, the following conclusions would be still more strongly sustained.

vestigations. Still it cannot fail to be evident from a survey of the tables, that the line between the Torrid and Temperate zones is a natural zoological limit.

II. The Torrid species of Brachyura (Torrid and Subtorrid Regions) greatly preponderate over those of the Temperate zone, the proportion being above two to one. This fact is the subject of remarks by Edwards, but with different conclusions from those which we would deduce.

III. The Frigid zone, as far as known, includes *one* species peculiar to it, the *Chionœcetes opilio.* And *Stenorhynchus phalangium*, *Hyas araneus*, *Portunus pusillus*, *Carcinus mænas*, and *Cancer pagurus*, are all that are known to extend into it from the Temperate zone. Perhaps the *Cancer chirogonus* from Kamtschatka (*Telmessus chirogonus* of White) should be added. This may be in part evidence of the little exploration hitherto made in the Frigid Seas. Yet, after the investigations of Beechey, Fabricius, Kröyer, Rathke, and others, we may be assured that the number of species is exceedingly small.

IV. Within the Temperate zone, the species are most numerous in the Warm Temperate, Temperate, and Subtemperate Regions; beyond this, the number diminishes, being a *quarter less* in the Cold Temperate than in the Subtemperate, and *half less* in the Subfrigid. Moreover, in the last-mentioned region, seventeen out of the thirty-nine species, or nearly one-half, occur in warmer temperate latitudes, only twenty species being confined to the Region.

V. In the Torrid zone, the species of the torrid region, amounting to three hundred and forty-eight, exceed in number those of the Subtorrid by only forty-five, although the Subtorrid region is not one-third as great, both as to surface and extent of coast line.

VI. Passing now from these general considerations respecting the Brachyura as a class to the several orders, we may look at their ratios among these orders and their subdivisions, for the several regions, in order to discover what is the relation of the species to temperature, and whether the cold or warm-water species are the higher or lower in grade, or whether the torrid or the temperate zone can claim species of the highest perfection or magnitude among the Brachyura.

The following table gives the ratio which the number of species of the several orders in the Temperate and Frigid zones, bears to that of the Torrid zone.

1. Maioidea,	1 : 1·3
2. Cancroidea,	1 : 3·3
3. Grapsoidea,	1 : 2·1
4. Leucosoidea,	1 : 2·0
5. Corystoidea,	1 : 0·3

It hence appears that the Maioidea and Corystoidea are proportionally much more abundant in the colder seas than the Cancroidea, Grapsoidea, or Leucosoidea.

If we examine into the subdivisions of the Maioidea and Cancroidea, we shall find the difference between the two groups in distribution more strikingly brought out. We shall find, moreover, that both groups may be divided into a warm-water and cold-water section, as below.

I. MAIOIDEA.

1. COLD WATER OR TEMPERATE ZONE SECTION.

	Torrid species.	Temperate species.
1. Inachidæ,	1	10
2. Maiidæ, subfamilies, *Libininæ, Maiinæ, Pisinæ, Othoninæ,*	15	35
3. Eurypodidæ,	0	7
4. Leptopodidæ,	1	8
	17	60

2. WARM WATER OR TORRID ZONE SECTION.

	Torrid.	Temperate.
1. Maiidæ, subfamilies *Micippinæ, Chorininæ, Pyrinæ,*	16	3
2. Mithracidæ,	11	6
3. Tychidæ,	4	0
4. Periceridæ,	43	14
5. Parthenopinea,	28	8
6. Oncininea,	2	0
	104	31

II. CANCROIDEA.

1. TEMPERATE ZONE SECTION.

	Torrid.	Temperate.
Cancridæ,	0	11
Platyonychidæ,	2	7
Portunidæ, subfamily *Portuninæ,*	0	15
Cyclinea,	0	1
	2	34

2. TORRID ZONE SECTION.

	Torrid.	Temperate.
Xanthidæ,	129	16
Eriphidæ,	44	12
Portunidæ, excluding the *Portuninæ,*	52	7
Podophthalmidæ,	2	0
	227	35

We have here two singular facts brought out.

First, that the cold-water section of the Cancroidea embraces those species that approach most nearly to the Corystoidea, and which we have elsewhere shown to be the *lowest* in grade of the Cancrinea. All have the lax character of the outer maxillipeds, which is a mark of degradation in the Corystoids; and the Cyclinea are still nearer that group. Many of the species moreover have the hind legs a swimming pair, another mark of degradation. The Corystoidea, as before shown, are two-thirds cold-water species.

Second, that the cold-water section of the Maioidea contains the species that are *highest* in grade, and largest in size. It is headed by the Macrocheira of Northern Japan, the king of all crabs, whose body is seventeen inches in length and a foot broad;

with extended legs, it sometimes covers a breadth of eleven feet, and the anterior legs or arms are *four feet* long!* The species of the other genera are mostly among the larger of the Maioids, and have no mark of inferiority. Such are the species of *Maia*, *Pisa*, *Libinia*, *Eurypodius*, etc.

But among the species of the warmer section, we find the Oncininea and Parthenopinea, both manifestly inferior in grade, the former approaching even the Anomoura, and the latter forming the passage of the Maioids to the Cancroids, as has been explained. We observe also the Periceridæ and the Tychidæ, all very small species, excepting a few Pericerae: the Menæthii, Tiariniæ, and Acanthonyces, are examples of the group. In addition, there are the Mithracidæ, which although attaining a large size show their inferiority in their shorter epistome, shorter body, which is sometimes even transverse, and their spoon-shaped fingers. In the last character, the Chlorodinæ among the Cancroids, similarly show their inferiority to the Xanthidæ. That this kind of finger is such a mark of inferiority is apparent from its diminishing in many species as the adult size of the animal is attained, the tendency being towards producing the acuminated finger found in the highest grades.

We are hence sustained in the conclusion that the Maioids of the Temperate zone are generally those that are highest in grade. It also shows the congeniality of cold waters to the Maioids, that the only Brachyuran peculiar to the Frigid zone is of this group. We refer to the Chionœcetes opilio.

VII. The Brachyura, therefore, although most numerous in the Torrid zone, do not reach in this zone their highest perfection. On the contrary, the Temperate zone or colder waters are the habitat of the highest species. Hence, as the Maioidea stand first among all Crustacea, the highest development of the class Crustacea takes place, not in the Torrid zone, the most profuse in life, but beyond the tropics and coral-reef seas, in the middle Temperate Regions.†

VIII. The prevalence also of the inferior Corystoids in the colder waters does not invalidate this conclusion, as the fact respecting the Maioids is wholly an independent one; for these last, by attaining their highest perfection in these coldest waters, determine the principle as regards themselves, the highest grade of Crustacea. Lower grades occur also in the colder waters, and the laws governing their distribution demand separate study and consideration.

IX. Passing a step below the Maioids, we come to the Cancroids, and these, with the exception of the lower Corystoid species, and only *one-eighth* of the rest, are Torrid zone species.

* De Haan's Fauna Japon., Crust. p. 101.

† On the coasts of Britain, the Cancroids (excluding the swimming species,) are only half as numerous as the Maioids.

X. If the Torrid zone is the proper region for the full development of the Cancroid type, and its heat is needed for this end, it is natural that species of Cancroids like the *Portuninæ*, *Platyonychidæ*, and *Cancridæ*, found in the less genial waters of the Temperate zone, should bear some mark of inferiority;—and it is a fact that they have such marks in their structure. This inferiority is not seen in their smaller size,—for a larger size under certain conditions, may equally evince a lower grade,—but in the inferior concentration of the life-system, exhibited either in the lax outer maxillipeds, the elongation of the antennæ and abdomen, or in the smaller size or swimming character of the posterior legs.

For a like reason also, the species of Corystoidea, a grade still lower, naturally occur in the cold and ungenial region they frequent.

We hence perceive, that the degradation among the Maioids takes place when the species become warm-water species, and the degradation among the Cancroids, in the reverse manner, when the species become cold-water species; for the reason that the colder waters are the proper habitat for the Maioid type, and the warmer for the Cancroid type.

XI. In the tables of the Maioidea and Cancroidea of the Temperate and Torrid zones, page 317, the species are included by families and subfamiles, and consequently the peculiarities of the genera are not shown. In the families or subfamilies referred to the cold-water section, there is only one warm-water genus, viz., *Doclea*, of the subfamily *Libininæ;* it contains four Torrid and one Temperate zone species.

Among those referred to the warm-water section, there are the following cold-water genera:—

			Species in Torrid zone.	Species in Temperate zone.
Parthenopinea,	genus	Eurynome,	0	2
"	"	Eurynolambrus,	0	1
Xanthidæ,	"	Paraxanthus,	0	2
Ozinæ,	"	Ozius,	2	3

The species of Cancrinea of the Torrid zone section, which reach farthest into the Temperate zone, are those of the following genera:—*Xantho*, which has eight Temperate zone species out of twenty-eight in all; *Panopeus*, which in the same way has four out of ten; *Pilumnus*, which has seven out of twenty-two; and *Lupa*, which has four out of ten. The cold Temperate Region is the highest for each of these genera, excepting Lupa and Pilumnus, a species of each of these latter genera extending just within the limits of the Subfrigid Region, on the coast of Massachusetts.

XII. The Grapsoidea, if divided between the Torrid zone and Temperate zone, according to families or subfamilies, will fall within the Torrid zone, excepting a single family of the Pinno-

theridæ, which contains eight species in the Torrid zone and fifteen in the Temperate. Considering the genera, however, we find that several among the Grapsidæ may be called cold-water genera, or are about equally divided between the Torrid and Temperate zones. They are as follows:

	Torrid species.	Temp'te species.
Pseudograpsus,	1	2
Heterograpsus,	0	1
Brachynotus,	0	1
Planes,	2	2
Hemigrapsus,	4	5
Cyrtograpsus,	0	1
Chasmagnathus,	2	2

Five out of twelve species of Grapsus also reach into the colder seas. Further particulars will be gathered from the tables.

XIII. The Leucosoids include as cold-water genera the following:

	Torrid.	Temperate.
Genus Ebalia,	0	8
" Ilia,	0	1

The other genera are mainly confined to the Torrid zone; out of the species they contain, sixty-seven in all, forty-eight are of this zone. *Hepatus*, however, contains as many cold-water as warm-water species, and the same is true of *Dorippe*, although but one of the species of the latter is exclusively Temperate.

XIV. The tropics afford not only a larger number of species of Brachyura than the temperate zone, but also a much greater proportion of individuals of the several species. Crustacean life, of this tribe, is far the most prolific in the warm waters of the globe. Species are very abundant about coral islands, far exceeding what may be found in other regions.

XV. The actual mass of Brachyura appears also to be the largest in the tropics, although there are genera, as Macrocheira and Cancer, which have their largest species in the colder waters, and which exceed in size any other Brachyura. The genera Atergatis, Carpilius, Xantho, Menippe, Zozymus, Eriphia, Thalamita, Charybdis, Calappa, besides others of the Torrid zone, contain many large species, which are of very common occurrence; while the cold-water genera of Maioids appear to be much less prolific in species, and the other genera, though abounding in individuals, as Cancer and Lupa, are still but few in number. Any very exact comparison, however, of the two zones in this particular cannot be made without more data than have yet been collected.

II. ANOUMOURA.

XVI. The Anoumoura are nearly equally divided between the torrid and temperate zones, there being hardly *one-tenth* more torrid than cold-water species. Only fifteen species out of two

hundred and twenty-five are common to the torrid and temperate zones.

Yet it is seen from the table, that if we except the Galatheidea, Lithodea, and part of the Paguridea, the species hardly extend beyond the warmer half of the temperate zone. There are but six known frigid species, and these are of the two last-mentioned groups.

XVII. The torrid zone and temperate zone sections of the Anomoura, are as follows; the frigid zone species being here added to the temperate.

1. TEMPERATE ZONE SECTION.

	Torrid zone.	Temperate zone.
Dromidæ, G. *Latreillia*,	0	3
Homola,	0	2
Bellidea,	0	2
Raninidea, G. *Notopus*,	0	1
Lyreidus,	0	1
Hippidea, G. *Albunhippa*,	0	2
Lithodea,	0	10
Porcellanidea,	27	20
Paguridæ, G. *Paguristes*,	3	6
Bernhardus,	3	29 { 1 torrid and 4 frigid.
Ægleidea,	0	2
Galatheidea, G. *Munida*,	0	2
Grimothea,	0	1
Galathea,	5	4

2. TORRID ZONE SECTION.

	Torrid zone.	Temperate zone.
Dromidæ, G. *Dynomene*,	1	0
Dromia,	8	2 (1 torrid).
Cymopolidæ, G. *Cymopolia*,	1	1
Caphyra,	2	0
Raninidea, G. *Raninoides*,	1	0
Ranina,	1	0
Ranilia,	1	0
Cosmonotus,	1	0
Hippidea, G. *Albunæa*,	3	3 (2 torrid).
Remipes,	5	1 (1 torrid).
Hippa,	2	2 (1 torrid).
Paguridæ, G. *Diogenes*,	5	2 (2 torrid).
Pagurus,	14	7 (1 torrid).
Calcinus,	6	0
Aniculus,	1	0
Clibanarius,	19	4
Cancellus,	1?	0?
Cenobitidæ,	10	1

The Dromidea and Paguridea have *one-third* to *one-fourth* more torrid than cold-water species.

The Raninidea and Hippidea are mainly tropical. The two extra-tropical species of Raninidea occur only in the warmer of the temperate regions, and the species of Hippidea in the temperate zone (eight out of the whole number fourteen) have among them four that occur also in the tropics.

The Lithodea belong to the coldest temperate regions, abounding especially in the subfrigid region. The Galatheidea are mainly of the temperate zone; there are five known torrid species, and seven temperate, the latter pertaining to the colder seas.

The genus *Porcellana* has but two-thirds as many species in the temperate as in the torrid zone. Yet the subtemperate region contains but one less than the subtorrid, and some of the largest species of the genus occur here; while, on the contrary, the torrid-zone species are quite small. Although, therefore, Porcellana may rank as a torrid zone genus, if we consider the relative number of species in the two zones, it is more properly a temperate zone genus.

The Paguridea range through both the tropics and temperate zone, even passing into the frigid zone. *Bernhardus* is mainly a cold-water genus, while Pagurus, Calcinus, and Clibanarius are mostly torrid genera. *Pagurus* has seven out of twenty-one species in the temperate zone. But it is in the torrid zone where the species of the largest size occur; the extra-torrid species belong almost exclusively to the Mediterranean. The species are exceedingly prolific in the tropics, far exceeding what occurs as regards any Paguridea in the temperate zone.

XVIII. It was found in the Brachyura, that the highest species among the Maioids, and the highest of Crustacea occur in the *extra-tropical* regions; and that as we descend to the Cancroids, the species become mainly *tropical;* moreover, as we descend among the Cancroids (the type of which is tropical), there is in general a return to the less genial colder waters, as exemplified in the true Cancers or Cancridæ and the Corystoidea, these last being mainly cold-water species. By these steps we find the more degraded forms among the Brachyura occurring in both the colder and warmer waters. We cannot therefore expect that the Anomoura, which are properly Brachyura of a still lower grade, should be arranged according to rank in one zone in preference to the other. And it is a fact that the genera of higher species occur about equally in the two zones. Latreillia, but a single step below the Inachidæ, is found in the warmer temperate regions; and Dromia, a little lower, has three-fourths of its species in the tropics. Homola, again, has been found only in the temperate zone.

Among the Paguridea, the Bernhardi or cold-water species are probably the superior in rank; and the Lithodea, which are a grade higher still, are from the neighborhood of the frigid zone.

The Hippidea, which we have considered as in the Corystoid series, but below the Corystoidea, are mostly from *warmer* waters.

The most bulky forms among the Anomoura are found in the genera Lithodes, Ranina, and Dromia. The common *Ranina dentata* has a length of five inches in the Japan Seas, while in

the warm East Indies (at the Moluccas), as De Haan states, four inches is the greatest length.

III. MACROURA.

XIX. The Macroura, according to the table, [see Report,] are nearly equally divided between the torrid and extra-torrid zones, the former including one hundred and forty-seven species, and the latter one hundred and fifty-three species.

In the table we have not included the fresh-water Astacidæ, as we are treating only of marine species. Yet in a comparison of numbers between the zones, these should be brought in. They are about thirty-six in number, and all, excepting perhaps one, belong to the temperate zone as regards the temperature of the waters they frequent. With this addition, the numbers become 147 for the torrid zone, and 189 for the extra-torrid. Sixteen of the cold-water species are common to both the torrid and temperate zones, and twenty-nine occur in the *frigid* zone, twenty-seven being peculiar to this zone. This is strikingly in contrast with the Brachyura, of which two-thirds are torrid species, and only five or six are known to extend into the cold zone, of which but *one* as far is known, is confined to it.

XX. The Thalassinidea are mainly extra-torrid species.

The Astacidea are divided between the warm and cold seas; the Palinuridæ and Scyllaridæ being mostly of the former, and the Astacidæ almost exclusively of the latter.

The Caridea spread largely over both zones; but extensive groups are extra-torrid, and some genera contain many frigid species.

The Penæidea are mainly of the torrid zone.

The exact ratios may be gathered from the tables.

XXI. The geographical relations of the subordinate groups are shown in the following table.

1. TEMPERATE AND FRIGID ZONE SECTION.

	Species in the Torrid zone.	Species in the Temperate and Frigid zones.
Thalassinidea,	6	17
Astacidea,	24	50
Astacidæ,	1	46
Scyllaridæ, G. *Arctus*,	0	1
Palinuridæ, G. *Palinurus*,	2	3
Caridea.		
Crangonidæ,	2	25
Atyidæ, *G. Ephyra*,	0	2
Palæmonidæ.		
Alpheinæ, G. *Betæus*,	1	4
Alope,	0	1
Athanas,	0	1
Hippolyte,	8	37 (19 frigid).
Pandalinæ, G. *Pandalus*,	0	4 (2 frigid).
Palæmoninæ, G. *Cryphiops*,	0	1
Pasiphæidæ, G. *Pasiphæa*,	0	3 (1 frigid).
Penæidea, G. *Eucopia*,	0	1 (frigid).

2. TORRID ZONE SECTION.

	Species in the Torrid zone.	Species in the Temperate and Frigid zones.
Astacidea.		
Scyllaridæ, except *Arctus*,	10	2
Palinuridæ, G. *Panulirus*,	12	1
Caridea.		
Atyinæ,	8	1
Palæmonidæ.		
Alpheinæ, G. *Alpheus*,	31	7
Palæmoninæ, G. *Pontonia*,	4	2
Œdipus,	3	0
Harpilius,	1	0
Anchistia,	3	0
Palæmonella,	2	0
Palæmon,	32	19 (1 frigid).
Hymenocera,	1	0
Oplophorinæ,	3	1
Penæidea,	19	12

XXII. Considering the Scyllaridæ and Palinuridæ as the Macroura highest in grade, this division of the Podophthalmia appears at first to have its superior developments in the tropics. But it may still be questioned whether this is altogether true. The Palinuridæ include two genera, one *Palinurus*, mainly a cold-water genus, the other *Panulirus*, a warm-water or Torrid zone genus; and is the Torrid zone genus the superior in rank, as should be the case, if the tropics are the most congenial to the highest Macroural developments? *Palinurus* has the outer antennæ nearly in contact at base, and the flagella of the inner antennæ are very short; *Panulirus*, the warm-water genus, has the outer antennæ remote at base, and the flagella of the inner antennæ very long. The genera are thus characterized by marks analogous to those that distinguish the higher and lower species among the Brachyura, or that exhibit the superiority of the Brachyura as a class over the Macroura; and if such evidence is here to be regarded, the cold-water genus, Palinurus, is the higher in rank. Moreover, the aspect of the Palinuri, the harder shell and more compact body, strike the eye at once as indicating their higher character. In size, they are not at all inferior; they even exceed the Panuliri in bulk if not in length. Among the Palinuri, one species is afforded by the warm seas of the West Indies; but it is not half the size lineally, of the *Lalandii* of the Cape of Good Hope, or the *vulgaris* of the Mediterranean, both gigantic species, sometimes a foot and a half in length independent of the antennæ.

The Astacidæ, the remaining family in the tribe Astacidea, is confined almost wholly to the colder waters, and the species are numerous.

Among the Caridea, the Crangonidæ certainly have the precedence. The fact that the first pair of legs have perfect hands, while the other legs are vergiform, shows a relation to the Brach-

yura, which is evidence of superiority. These Crangonidæ, thus the highest of the Caridea, are almost exclusively cold-water species.

In the family Palæmonidæ, some genera have the anterior legs furnished with stout hands, while in others the second is the stout chelate pair. The former, for the reason just alluded to while speaking of the Crangonidæ, and elsewhere further explained, are superior in rank. It is among these genera of this superior grade, the Alpheinæ, that we find the cold-water and boreal species. The genus Hippolyte alone contains thirty-seven cold-water species, nineteen of which are of the Frigid zone; and there are only eight torrid species.

On the contrary, among the Palæmoninæ, the inferior group, there are forty-six torrid to twenty-two extra-torrid species; and only one of the latter is boreal. Species of Alpheus are common in the tropics about coral-reefs; but the largest species of the genus, two or three inches long, occur beyond the tropics.

The Penæidea, the lowest of the tribes of Macroura, are mainly tropical. Yet, the very lowest species (like the lowest Brachyura) occur partly in the colder waters, or even in the Frigid zone.

XXIII. Comparing the torrid and temperate species of Macroura, we are led to conclude, that the latter are probably most numerous in individuals, and the most bulky in mass. Excepting the Panuliri, Scyllari, and some Palæmons, the tropical species are small, and moreover, they are not particularly abundant about coral-reefs. The species of the torrid genera, Pontonia, Œdipus, Harpilius, Anchistia, Palæmonella, Hymenocera, and Atya, are all quite small, the greater part not exceeding an inch and a quarter in length; moreover, the tropical Alphei are also small species, as stated above. The Penæidea are partly larger species. Contrast these particulars with the facts as to the genera of the Temperate zone. Palinurus, Astacus, Nephrops, Paranephrops, Homarus, Arctus, Crangon and the related genera, Hippolyte, Pandalus, Cryphiops, contain species mostly of large size, and the adult Homari and Palinuri are not exceeded in weight by any other Macroura.

The Thalassinidea, which belong almost exclusively to the temperate regions are smallest in the warmer part of the Temperate zone, and larger in the middle and colder part. A Puget Sound species (subfrigid region) of Callianassa (C. gigas) is at least four and a half inches long, the *C. uncinata* of Chili, five inches, and the *Thalassina scorpionides* of Chili, six inches. The facts respecting this subtribe, added to those mentioned above, strengthen much the conclusion, that the cold-water genera have the largest species; for all the species are over an inch and a half in length.

IV. ANOMOBRANCHIATA.

XXIV. The Mysidea, to which the Penæidea are related, are, to a considerable extent, cold-water species, although many are found also in the tropics. There are among them twenty torrid species and seventeen extra-torrid species.

In the Squilloidea we have an example of an inferior grade in a large lax body, with a small head and long abdomen; and they remind us of overgrown larval forms, or species vegetatively enlarged beyond the normal or most efficient size. In this particular they have some analogies with the earlier forms of life. They are found mostly within the tropics. Twenty-four of the Squillidæ are torrid zone species, and only seven pertain exclusively to the Temperate zone. Of the Erichthidæ, twenty-one out of twenty-two species are reported from the Torrid zone. The Amphionidea, a related group, include seventeen Torrid zone species and two of the Temperate zone.

(*To be continued.*)

Art. XXXV.—*Notes on Map Projections;** by Lieut. E. B. Hunt, Corps of Engineers, U. S. A.

MAP PROJECTIONS CLASSIFIED AND DEFINED.

That department of descriptive geometry, or analysis, which treats of map and chart projections, has to deal solely with the terrestrial spheroid, and especially with the representation of the parallels and meridians subdividing its surface. As all localities, both on land and sea, are most readily and generally determined by latitude and longitude observations, so it is the most available and universal method, in constructing maps, to refer all positions to meridians and parallels as coördinate lines.

If we conceive the earth's surface reticulated by a complete framework of parallels and meridians, it is then the specific and uniform object of all modes of projection to represent these lines on a plane surface, in the most advantageous manner. But, as the spheroid is incapable of direct development on a plane, it only remains to present, in projection, the *best* approximation to similitude in form, relation, and proportional area in the parts of the earth's surface to be represented.

Ptolemy, Lambert, Euler, Lagrange, De l'Isle, Monge, La Croix, Puissant, Henry, Gauss, and others, have treated of projections in more or less detail, and some of them by methods of

* Extracted with modifications from the Coast Survey Report for 1853, in which is also included the formulæ for polyconic projections, with full tables and a description. The Tables suffice for the entire United States on either a large or small scale.

the highest grasp and compass.* This general problem has led to the following modes of projections, (all technically, though some quite incorrectly so called,) each of which has been used, and most of which possess advantages for some descriptions of maps or charts. This classified synopsis will serve to show more precisely the relative value and precise character of the polyconic projection.

CLASS I.—Perspective projections on planes,	Orthographic. Globular, or equidistant. Stereographic. Gnomonic, or central.
CLASS II.—Developed perspective projections,	By a tangent cylinder. By a secant cylinder. By a tangent cone. By a secant cone.
CLASS III.—Projections by developing elements,	Cassini's. Flamstead's. Bonne's, or the modified Flamstead's. Polyconic, (U. S. Coast Survey.)
CLASS IV.—Projections conformed to some arbitrary condition,	The flat chart, with equal latitude degrees. The flat chart, with latitudes = radius × sine of latitude. De Lorgna's. Ptolemy's modified conic. Mercator's.

CLASS I.

All simple perspective projections are made by supposing the eye at some particular point, and the plane of projection or representation to be pierced by all the rays, or rays prolonged, between the eye and all points of the parallels and meridians. The curves composed of all these piercing points of rays constitute a perspective projection. A projection is practicable for any possible position of the eye or plane, (except when the eye is in the plane,) but only a few among this infinite number of perspectives are convenient or eligible for construction.

In the *orthographic* projection the eye is assumed at an infinite distance, and the projecting rays are parallel lines to which the plane of projection is perpendicular at any point desired. By this method circles are projected into ellipses, and the outer parts of the projected hemisphere are very much crowded.

In the *globular* or *equidistant* projection, originated by La Hire, the eye is placed at a distance from the centre of the earth $=$ Radius $+$ sine $45° = (1+\sqrt{\tfrac{1}{2}})$ radius. The plane of projec-

* Reference on this subject may be made with advantage to the following general treatises: Puissant, "Traité de Topographie," 1805; Henry, "Memoire sur la projection des Cartes," 1810; "Memorial du Depot de la Guerre," tome ii. and iv; La Croix, "Precis Astronomique," in "Pinkerton's Geography;" Barbié Dubocage, and La Croix, vol. i, "Memorial Topographique et Militaire," Francoeur's "Traité de Geodesie;" Gehler, "Physickalisches Worterbuch;" Mayer's "Practical Geometry," 1828; "Littrow's Astronomy," 1812; Narrien's "Astronomy and Geodesy," 1845; Jackson's "Chartography," in "Manual of Geographical Science," 1852.

tion passes through the centre perpendicular to the central ray. This projection obviates the orthographic contraction or crowding and the stereographic exaggeration in the outer rim of a projected hemisphere.

In the *stereographic* projection, the eye is taken on the surface of the earth at the pole of the great circle used as a plane of projection. Circles are stereographically projected into circles. An increasing exaggeration of parts from the centre outwards is its great defect.

In the *gnomonic* or central projection, the projection is on a tangent plane—the eye is taken at the centre of the sphere. Great circles are gnomonically projected into straight lines, and all small circles into curves of the second order or conic sections. The entire hemisphere cannot thus be projected, and the portions become rapidly exaggerated in receding from the tangent points.

CLASS II.

Instead of projecting directly on planes, an intermediate cylinder or cone is employed in this class to receive the projection, which is then developed or rolled out on a tangent plane. The cylinder and cone being the only surfaces which can be developed by simple rolling out, and without elementary resolution, this class always requires the auxiliary use of one of these surfaces, which may be assumed, subject to several different conditions.

The projection on a *tangent cylinder* for development is made by placing the eye at the centre of the earth, and projecting the parallels and meridians on a cylinder tangent around the equator. On development, the parallels and meridians are found projected into perpendicular straight lines.

A *secant cylinder* may be so determined that the entire area of the spherical zone projected shall be exactly equivalent to its projection. These methods are limited in their advantageous application to a moderate equatorial belt.

In projecting perspectively on a *tangent cone* for development, the eye is assumed at the earth's centre, and the cone is taken tangent around the middle parallel of the zone to be projected. On developing this cone, the meridians appear as straight lines radiating from its vertex, and the parallels as circular arcs concentric around this point, the middle parallel being in its true length.

A *secant cone* may be taken which will give two parallels of correct length in the development, and much reduce the distortion of the extreme belts. This method of Ptolemy was revived by Mercator, and was used by De L'Isle in his map of Russia. Murdoch proposed to make the area of the conic frustum used equal to that of the projected spherical zone—a good condition, though inconvenient in construction. De L'Isle proposed to use a cone, through the limiting parallels. Euler proposed and de-

termined the cone which equalizes the errors and distortion on the central and the two limiting parallels. The use of two conic frustums—one for the north and one for the south half—has also been attempted, and advocated.

CLASS III.

The class of projections in which portions of the spherical surface are developed by being resolved into their differential elements, which are successively developed, is characterized by a peculiar elegance, and is of the highest importance. By this means, any portion of a spherical or spheroidal surface may be reconstructed on a plane with the most perfect attainable preservation of the relations and dimensions of its parts. This class of projections is far the best for representing limited areas, and can even be extended with advantage in some forms to *mappemondes*, or maps of the entire earth's surface.

Cassini's projection is made by first developing the central meridian of the area for projection into a straight line. A series of prime verticals or great circles perpendicular to their central meridian is passed at elementary distances along the meridian arc, all of which circles intersect in the spheric poles of the central meridian. These divide the surface into elementary rectangular isosceles triangles, or sectors, basing on the meridian elements. When the meridian is developed, these elementary triangles are conceived to be carried with it, and then to be severally developed into plane triangular elements. The elementary opening out between these developed areas may be neglected for some distance from the central meridian. Accordingly, a series of perpendicular straight lines through the graduations of the developed central meridian is taken as a substitute for parallels, and may be used as far as the opening out between elements can be neglected. Cassini's Map of France is thus projected; but, as its inaccuracy on the extreme east and west sheets amounts to 150 toises in 40,000, the use of this projection is not to be recommended for areas thus extensive. Du Séjour has developed the theory and formulæ of this method. As parallels of latitude do not enter, the latitudes of places must be derived indirectly, except on the central meridian.

Flamstead's projection is based on a resolution of the earth's surface into elementary zones or rings by parallels of latitude taken at successive elementary distances laid off along the central meridian of the area to be projected. Having developed this centre meridian on a straight line of the plane of projection, a series of perpendiculars is conceived to be erected at the elementary distances along this line. On or between these perpendiculars the elementary zones are conceived to be developed in their correct relations to each other and to the central meridian. Each

zone being of uniform width, occupies a constant breadth along its entire developed length, and consequently the area of the plane projection is exactly equal to that of the spheroidal surface thus developed. This demonstration applies directly to an analogous plane development of the surface of all supposable surfaces of revolution, be the generating meridian curve what it may, and even though the generatrix be one of double curvature. The meridians of the developed spheroid are traced through the same points of the parallels in which they before intersected them. They all cut the parallels obliquely, and are concave towards the central meridian. Thus, while each quadrilateral between parallels and meridians contains the same area and points after developments as before, the form of configuration is considerably distorted in receding from the central meridian, and the obliquity of intersections between parallels and meridians grows to be highly unnatural.

Bonne's, or the *modified Flamstead's* projection, to a great extent obviates this defect. It is the same as Flamstead's, except that the elementary zones, instead of being developed on right lines, are rolled out on concentric circular arcs described from the vertex of the cone tangent along the central parallel for their common centre. The great importance and wide use of this method induce a more detailed treatment of it under a subjoined heading.

The *polyconic projection*, being that for which the Coast Survey tables are prepared, will be specially explained further on in its proper place.

CLASS IV.

In addition to the perspective projections, the developed perspective, and the elementary development projections, there is a class in which some extraneous, arbitrary mathematical condition is imposed, giving rise to constrained or distorted delineations. The assumed condition is usually due to some practical consideration.

The *flat-chart* projection, with *equal latitude* degrees, is a rude method once much in use for charts. Two sets of equidistant perpendicular lines, composing a series of equal squares, were arbitrarily assumed as parallels and meridians to which all localities were referred by latitudes and longitudes. Hence resulted a gross distortion of figures, areas, and directions.

Another *flat-chart* projection was sometimes used, in which equidistant straight lines served as meridians; and for parallels a second set of straight perpendiculars at distances from the equator equal to those of the respective terrestrial parallels for which they stand. This is a radial projection on the circumscribing cylinder tangent along the equator, the radii of parallels being the only

projecting lines. Hence resulted a very distorted picture, but one in which each quadrilateral contains an area equal to and corresponding with its spherical correlative—a direct result of the relation between the sphere and circumscribing cylinder. This was the sole recommendation of the method.

De Lorgna's projection is chiefly employed as a polar projection of a hemisphere, for which use it is well adapted. A circle is determined equivalent in area to the hemisphere to be projected. Radii drawn to the graduations of its circumference represent meridians. A radius, graduated into ninety equal parts, is sometimes used as the latitude scale; but the chords of the polar distance of the parallels should be always employed. Hence results equality of areas between the projected and resultant quadrilaterals in general. Outlines are traced by latitudes and longitudes, as usual. For projecting a polar hemisphere, this method is most excellent, as rectangular intersection is combined with conservation both of figure and area.

Ptolemy's modified conic projection is made by using the concentric parallels of the pure conic development, and tracing curved or elliptical meridians across these in place of radial lines. By turning the convexities of these curves from the central line, and by skillful choice of curves, much of the distortion due to the extension of extreme parallels in development is obviated. This projection has been much used for maps of Asia, Africa, and America.

Mercator's projection is truly invaluable for navigators in laying long courses when out of sight of land, as these courses are always straight lines on the chart. Meridians are represented by equidistant parallel straight lines, and the parallels by a perpendicular set of parallel straight lines, whose distances from each other increase from the equator towards the poles in precisely the same ratio as the corresponding longitude degrees diminish. This projection results from the development of a cylinder tangent along the equator; the meridians being projected on their tangent elements, and the parallels being assumed as circles of right cross section at distances from the equator equal to the meridian arc of latitude divided by the cosine of the latitude—the earth's compression being neglected. By this means the relation of length between the latitude and longitude measurements on the chart is preserved uniformly the same as it is on the earth's surface. Tables of the increasing degrees have been computed, and are in general use for laying down parallels. Distances and areas are increasingly exaggerated and distorted as this projection is pushed towards the pole, making the scale very variable from point to point of an extended chart; but as the navigator computes his distance run, this variable scale is not by any means so serious a defect as to offset the invaluable facility with which

Mercator's principle enables him to run directly from one point to another. For the polar portion of the earth in which this projection totally fails, a central projection can be used to some distance. A projection on Mercator's principle might be made relative to the prime meridian instead of the equator, its prime verticals serving as the equidistant parallels, (as in Cassini's) and the circles parallel to the prime meridian being projected by the table of increasing degrees. This would require the investigation of the formulæ for conversion of coördinates in this case. The parallels and meridians of the earth might then be constructed by points. Another mode would be to make a radial and concentric circular projection around the pole, in which the length of the latitude degree should be deduced from the same condition as in Mercator's method, the divergence of meridians being duly considered. The amount of distortion in Mercator's projection wholly unfits it for land maps; and the variation of its scale in different parts would give rise to endless inconvenience were it applied to any other purpose than that of nautical offshore charts, in which direction is so much more important than area or distance.

BONNE'S OR THE MODIFIED FLAMSTEAD'S PROJECTION.

This method of projection is that which has been almost universally applied to the detailed topographical maps based on the trigonometrical surveys of the several States of Europe. It was originated by Bonne, was thoroughly investigated by Henry and Puissant in connexion with the map of France, and tables for France were computed by Plessis.

In constructing a map on this projection, a central meridian and a central parallel are first assumed. A cone tangent along the central parallel is assumed, the central meridian is developed on that element of this cone which is tangent to it, and the cone is then developed on a tangent plane. The parallel falls into an arc with its centre at the vertex, and the meridian into a graduated right line. Concentric circles are conceived to be traced through points of this meridian taken at elementary distances along its length. The zones of the sphere lying between the parallels through these points are next conceived to be developed each between its corresponding arcs. Thus, all the parallel zones of the sphere are rolled out on a plane in their true relations to each other and to the central meridian, each having in projection the same width, length, and relation to its neighboring zones, as on the spheroidal surface. As there are no openings between consecutive developed elements, the total area must in this case, and in all like developments of surfaces of revolution, remain wholly unaltered by the development. Each meridian of the projection is so traced as to cut each parallel in the same point in which it intersected it on the sphere.

If the case in hand be that involving the greatest extension of the method, or that of the projection of the entire spheroidal surface, a prime or central meridian must first be chosen, one half of which gives the central straight line of the development, and the other half cuts the zones apart, and becomes the outer boundary of the total developed figure. Next, the latitude of the governing parallel must be assumed; thus fixing the centre of all the concentric circles of development. Having then drawn a straight line and graduated it from 90° north latitude to 90° south latitude, and having fixed the vertex or centre of development on it, concentric arcs are traced from this centre through each graduation. On each parallel the longitude graduations are then laid off, and the meridians are traced through the corresponding points. There results from this process an oblong kidney-shaped figure, which represents the entire earth's surface, and the boundary line of which is the double developed lower half of the meridian first assumed. If the vertex of the governing cone be removed to an infinite distance, the equator becomes the governing parallel, the parallels all fall into straight lines, and Flamstead's projection results. The kidney-shaped figure becomes an elongated oval, with the half meridian for one axis, and the whole equator for the other. A somewhat similar figure is obtained by placing the vertex at the pole, and reducing the tangent cone to a plane. An indented cusp at one end, and a rounding out at the other, will give an approximate pear-shape. Ptolemy's modified conic method reaches its full geometrical result in these forms, derived from the condition of *preserving areas* in tracing meridian curves.

Bonne's method is rarely applied to areas exceeding the limits of a State, but is invaluable for topographical maps of this description. The projection is made at once for the whole territory of the map, and the rectangular system of sheets laid out on the projection. Each sheet is numbered, and the coördinates of the corners are determined, so that the coördinates of intersection between parallels and meridians falling on each sheet are referred to its neat lines as axes.

This projection preserves in all cases the areas developed without any change. The meridians intersect the central parallel at right angles; and along this, as along the central meridian, the map is strictly correct. For moderate areas, the intersections approach tolerably to being rectangular. All distances along parallels are correct; but distances along the meridians are increased in projection in the same ratio as the cosine of the angle between the radius of the parallel and the tangent to the meridian at the point of intersection is diminished. Thus, in a full earth projection, the bounding meridian is elongated to about twice its original length. While each quadrilateral of projection preserves

its area unchanged, its two diagonals become unequal; one increasing and the other diminishing in receding towards the corners of the map, the greatest inequality being towards the east and west polar corners. Though great circles between stations on the earth are generally projected into curves, the amount of deviation for moderate limits is very slight on a Bonne projection. The scale is nearly uniform over the entire projection, being accurate along the parallels and along their radii, but being too great along one diagonal of the quadrilaterals, and too small along the other. In an area of 120° longitude and 70° latitude, a distance of 7,000 miles is in error but $\frac{1}{33}$th. This projection has thus many excellent qualities for topographical maps; and its defects of oblique intersections, of unequal diagonals, and of scales varying with the point of the compass, are not very serious in a limited area, as in the map of France, or that of England and Wales. A special set of tables for each central parallel is required in this method; and the extent of these is so vast as to make impracticable the conception of a universal set of tables. The French tables of Plessis are based on the parallel of 50^{gr}. or 45°, and are available for any area centered on this line, except that the old compression was used in computing them. But to construct tables for Bonne's projection for use in the disconnected local maps of our country was impracticable, as no central parallel could be assumed for them all. Were a general topographical map of the United States to be made, a central parallel might be assumed for that purpose; but even in this case the question should be carefully weighed, whether the Bonne projection would be as desirable as the rectangular polyconic.

THE POLYCONIC PROJECTION, ITS PROPERTIES AND VARIETIES.

The operations of the coast survey being limited to a narrow belt along the seaboard, and not being intended to furnish a map of the country in regular uniform sheets, it is preferred to make an independent projection for each plane-table and hydrographic sheet, by means of its own central meridian. These sheets embrace areas so limited as to exhibit in projection no sensible distortion of figure, and they individually agree with nature far more perfectly than they would if arranged as parts of a rectangular series projected on Bonne's method. In fact, each sheet is projected strictly as a local map, and its connexion with the adjoining sheets is established solely by the points of triangulation. In reductions, including several sheets, the plotting of points is the first step, and the change of scale is then made by corresponding squares. By the aid of the coast-survey tables, a *rectangular polyconic* projection can at once be made for each locality or subdivision of the United States, or for the United States as a whole.

The name *rectangular polyconic* projection is applied to the method in which each parallel of the spheroid is developed symmetrically from an assumed central meridian by means of the cone tangent along its circumference. Supposing each element thus developed relative to the common central meridian, it is evident that a projection results in which all intersections of parallels and meridians take place at right-angles.

Let the most general case, or that of the entire spheroid, be first assumed, the development being made, for instance, relative to the meridian of Washington. Starting at the north pole, the tangent cone there has then its limiting form, or it coincides with the tangent plane. Taking then the elementary parallels successively southward, the vertex of the moving tangent cone recedes along the prolonged earth's axis, giving to the developed parallels a receding centre and an increasing radius as the latitude diminishes. At latitude 45° the terrestrial and development radii become equal. At the equator the vertex recedes to an infinite distance north, or the cone becomes a cylinder, and the equator falls in a straight line perpendicular to the meridian. On passing to the south the vertex approaches from an infinite distance south, the parallels change their concavity southward, while the curvature, increasing in an inverse order, becomes infinite at the pole, or the polar parallel falls in a point. There results from this process a biaxial figure, with four equal quadrants, the short axis being the rectified Washington meridian, (180° in length) and the long axis being the entire rectified equator, or about twice the length of the shorter one. A re-entering cusp marks the bounding curve at each pole, and the meridian, 180° from Washington, which circumscribes each half of the figure, is elongated on each side to more than twice its original length by the development. Over the entire area of this projection all parallels and meridians intersect at right angles, and the diagonals of each projected quadrilateral are everywhere nearly equal to each other. The scale on N. and S. lines near the border is somewhat enlarged, but is very correct on E. and W. lines, while along both diagonals it is somewhat enlarged, though nearly equally so on each. On the whole there results from this method much less of local distortion than from Bonne's projection. Equality between the spheroidal and developed areas is not preserved, but the departure from equivalency is not great in amount.

As rectangular intersections and preservation of areas are not both attainable at once, it becomes a question of preference between them in each case. It is also a question whether it might not in some cases be advantageous still further to sacrifice the preservation of areas so as to make the same scale applicable in all azimuths at each point. This would require the longitude degrees to increase from the centre meridian outwards in the

same ratio as the corresponding projected meridional degrees. This condition would determine a new polyconic projection, whose scale, from point to point, (an element which in Bonne's, and the simple polyconic projection, is a function both of the central meridian distance, and azimuth) would become a function of the central meridian distance only, and would increase alike in all directions on receding from this line. Such a projection would reduce distortion of local configuration, to an absolute minimum, and the areas in projection would be proportional to the squares of their local graphic degrees. This would enable us to take strict account of those irregularities of scale which now lurk in disguise. But it would be a great labor to prepare the tables requisite for its ready use, and there would be some valid objections to its results. In a large topographical map thus projected, the scale of each sheet could be derived and engraved on its plate, making the sheet quite homogeneous on that scale, and perfect in the preservation of its configuration. Were a topographical map of the United States to be undertaken on a liberal scale, this projection might be found superior to any other, as in each sheet areas, dimensions, relations, and rectangular intersections, would be well preserved according to its own scale, giving it the greatest local perfection, while it would also combine correctly in its proper place. It should be stated that this projection is novel and untried.

The method of projection in common use in the Coast Survey office for small areas, such as those of plane-table and hydrographic sheets, may be called the *equidistant polyconic.* This ought to be regarded rather as a convenient graphic approximation, admissible within certain limits, than as a distinct projection, though it is capable of being extended to the largest areas, and with results quite peculiar to itself. In constructing such a projection the central meridian and a central parallel are chosen, and they are constructed just as in the rectangular polyconic method. The top or bottom parallel, and a sufficient number of intermediate ones to determine the meridians with proper correctness, are constructed by the tables, and the meridians are drawn. Then starting from the central parallel, the distance to the next parallel is taken from the central meridian and laid off on each other meridian. A parallel is traced through the points thus found. Each parallel is constructed by laying off equal distances on the meridians in like manner, and the tabular auxiliary parallels are, all except the central one, erased. In fact, as only the points of intersection are required, the auxiliary parallels should not be actually drawn. From this process of construction results a projection in which equal meridian distances are everywhere intercepted between the same parallels.

If we conceive this projection extended to include the entire earth, a singular result appears. Taking the equator as the central parallel, all the parallels become concave towards this line; for the distance between parallels measured along the curved meridians being constructed equal to that along the central straight meridian, it is evident that the parallels must converge in receding from the central meridian. The parallel of 90°, or the polar point, becomes extended into a curve, whose length approaches that of the developed equator. It will be seen that each parallel falls nearer the equator than it would in Flamstead's projection, being, indeed, tangent on the equatorial side of the Flamstead perpendicular. Thus, in this method the projected area is less than that of the spheroidal surface. If an equidistant polyconic projection be made on the same central meridian and parallel as a Bonne projection, its area will in like manner be less for each rectangle and for the aggregate; hence this projection, where extended to a great surface, always gives its area too small. It also makes its meridian arcs unduly short, and the extreme parallels much too long; giving a grotesqueness to the polar regions bordering on that of a Mercator projection. The scale becomes in some parts excessively dependent on azimuth; the distortion in the polar corners is very great; the intersections are far from rectangular, and they are so conditioned as not to be readily computed. From these defects, so gross in the developed spheroid, and still great even in a map of the United States, it is clear that the *polyconic-equidistant* projection ought by no means to be extended beyond the most moderate limits. A square degree, on a scale of $\frac{1}{10000}$, may be taken as a limit, beyond which no convenience of graphic construction should induce the use of this approximation. Beyond this limit the *rectangular-polyconic* method should be employed, at least in all Coast Survey projections.

The polyconic method of projection has been developed in the Coast Survey office, and tables, prepared for facilitating its use, were there computed, and are now first published in the Report for 1853.

GRAPHIC CONSTRUCTION OF POLYCONIC PROJECTIONS—COAST SURVEY METHODS.

Having fixed the limits to be covered by the projection, the central meridian is represented by a straight line, as nearly as practicable, through the centre of the sheet. From an assumed starting-point on this line are laid off the successive meridian arcs, as taken from the tables.

Rectangular polyconic method.

Through each point of division on the central meridian, given by these tabular arcs, erect a perpendicular to it by means of a

well-tested right-angled ruler, with twenty-four inch legs, and a hard pencil; or first carefully construct a single accurate perpendicular by sweeping intersecting arcs with the beam-compass, and then draw on each side a parallel to the central meridian, on which lay off the meridian distance from the perpendicular, and draw the parallel lines through the three equidistant points thus obtained for each. Take from the tables for each required point of intersection between parallels and meridians, its appropriate length of arc of parallel, from which subtract the corresponding x. Lay off this difference from the central meridian each way on its proper perpendicular, and erect, towards the pole, at the point so formed, a perpendicular equal to the corresponding value of y in the tables—its extremity is the point of intersection required. Through all the corresponding points of intersection trace the parallels and the meridians. Erase the auxiliary lines, and write on the margin the numerical latitude and longitude.

The following mode is more rapid and better checked: Lay off first the longest arcs of parallel, and then take the length of a single subdivision of the parallel in a pair of hair-spring dividers, and step it off on the perpendicular to the right and left of the central meridian, being careful not to prick the paper. Having adjusted the dividers so as to bring the extreme points thus obtained to a perfect agreement, prick lightly the subdivision points. Take from the tables the successive values of x for each point, and when these are sensible on the scale used, lay them off back towards the central meridian from the points before obtained, and erect, at the last points, perpendiculars equal to their respective values of y. As x is always small, and for some entire projections quite insensible, this method is much more convenient than that of using all the while long distances; but the check of a total measurement on each parallel is quite indispensable, as an insensible error in taking the subdivision distances grows, by repetition, to be very evident in the check measurement.

Equidistant polyconic method—(*Inadmissible in projections covering more than one square degree.*)

Proceed as before to graduate the central meridian, and to construct a central parallel. Construct the points of meridian intersection with the top and bottom parallels, and as many intermediate parallels as are requisite closely to determine the meridians. Through these points then draw the meridians. Starting now from the central parallel, lay off on each meridian the distance to the required parallel equal to that on the central meridian, and trace the parallels through these points. Proceed in like manner to construct the others, using always the central parallel as a base, and the totals measured from it along the central meridian in laying off.

This method requires much less recourse to the tables than the other, and is sufficiently accurate, within a square degree, on a scale of $\frac{1}{1000000}$. The x and y may often be neglected as insensible in small projections; but no value of x, which is at all appreciable on the scale used, should be neglected. The y, for the auxiliary parallels, affects the meridian less rapidly, but its palpably sensible values should always be used.

The following quantities are sensible, yet only barely sensible, on the scales affixed:

12	metres	on a scale of	$\frac{1}{60000}$.
10	"	"	$\frac{1}{50000}$.
8	"	"	$\frac{1}{40000}$.
6 or 5	"	"	$\frac{1}{30000}$.
3	"	"	$\frac{1}{20000}$.
$1\frac{1}{2}$ or 2	"	"	$\frac{1}{10000}$.

These quantities are quite overshadowed in large sheets by the expansion and shrinkage of drawing-paper from day to day. In both methods the x and y should always be used for good projections when they would be sensible on the scale in use. And it is peculiarly essential to accurate projections that the hygrometric condition of the paper be kept as uniform as possible during all the time that measured distances are being laid down. It is often better to mark simply the intersection points by a small cross +, and to omit the remainder of the parallels and meridians. For plotted points this is also the best indication, if the cross lines are stopped on each side of the point, just far enough off to leave the dot distinct.

For drawing parallels and meridian curves, a long, slender, flexible ruler of straight-grained cedar, or other compact wood, is employed. Its cross section is three-sixteenths ($\frac{3}{16}$) of an inch by two sixteenths ($\frac{2}{16}$) of an inch. A specially designed steel ruler might be found preferable. There is a small groove on the top of the ruler, and its ruling edge is slightly beveled. Leaden, paper-covered, beak weights, of about four pounds weight each, are used to hold the ruler in place from point to point. These are so shaped as not to incommode the hand in ruling, and each has a hooked beak, ending in a knife-edge, turned downwards, which, resting in the ruler groove, throws the main bearing of the weight on the ruler, while its small end rests on the paper. The beak weights in use are five (5) inches long, two and one-eighth ($2\frac{1}{8}$) wide, and two and one-eighth ($2\frac{1}{8}$) deep, the beak being five-eighths ($\frac{5}{8}$) of an inch long, and turned down one-fourth ($\frac{1}{4}$) inch. The mass of lead is nearer the beak end. Having placed the ruler approximately, it is so adjusted under a beak weight to the first point that the curve will be ruled exactly through it. It is then adjusted under a second weight to the

next point, and then bent to the next in like manner, and so on until the entire curve is completed. Before ruling this the eye should criticise it carefully, as a check on graphic errors. For fine projections the hardest pencils are best; and in inking, the lines should be drawn as delicately as clearness permits.

When no metre scale is at hand, the tabulated distances can be converted into yards by using the conversion tables, or by the constants of relation between units; or, when the greatest accuracy is not important, a metre scale can readily be constructed from a yard or foot scale by proportionality. Thus, rule two parallel scales, one of yards and one of five-sixths ($\frac{5}{6}$) yards, and draw a third parallel, whose distance outside the yard-scale is $\frac{3.3685}{6}$th of that between the yard and five-sixth yard scales. Through the similar graduations draw straight lines; these will give a metre scale by their intersections. If space permits, a point may be substituted for the five-sixths ($\frac{5}{6}$) yard scale. The projection once constructed, may be used independent of the unit of the tables.

Art. XXXVI.—*On the Educational Uses of Museums;* by Edward Forbes, F.R.S., &c.*

The third Session of the Government School of Science applied to Mining and the Arts commences to-day. The Director and my Colleagues have assigned to me this year the duty of opening the courses. I shall avail myself of this opportunity to offer some remarks upon the leading and characteristic features of the Institution, considered as an educational Museum, and to make some observations upon the instructional uses to which Museums may be advantageously applied.

The school of applied sciences here established is the only instance in Britain of an organized instructional institution arising out of a Museum, and being maintained in strict connection and relation with its origin. This is not an accident, but an event contemplated from the commencement of the Geological Survey. It is an experiment on a considerable scale with a greater purpose,—for, with a limited though rapidly improving machinery, it is intended to advance educational aims that have a vital importance in their bearing on the future prospects of this country. It is an endeavor by a State-mechanism to cast the seeds of science over the broad fields of British industry,—not indiscriminately, but especially in those places where there is a good soil thirsting for their germination. We who are appointed to be

* Introductory Lecture at the Metropolitan School of Science, etc.; Museum of Practical Geology. London, 1853.

cultivators have a responsible duty and a noble task. We have firm faith in the dignity our work, and in the certainty of good results arising from it. This must be our reward; and with it we are content, as long as we can, to labor patiently and earnestly to the best of our endeavors,—hopeful of the approbation and coöperation not only of our fellow-laborers in science, but also of all intelligent and patriotic Britons.

The results so far of the teaching here have been in the main highly satisfactory. With the close of last session terminated the two years curriculum of the students who entered the Government School of Mines in 1851. Since their studies are now completed, I may speak of the men in the language not of compliment, for of that there is no necessity, but of unmixed praise. I can say this not only for myself but for all my colleagues; and we have the delightful satisfaction of anticipating a distinguished scientific and practical career for those who were lately our pupils, and whom now we number among esteemed friends. Their services are sure to be appreciated and anxiously sought for; and already we have had the pleasure of congratulating some of them on the obtainment of highly valuable and honorable posts, for which they had become qualified within these walls.

With equal satisfaction we can refer to the department of our lectures devoted to the instruction of working men. The artisans of London have eagerly and admirably responded to the opportunity so freely offered to them by Government in this Institution. They have crowded to our theatre and attended our courses with unmistakable earnestness and intelligence. To address the audience, composed exclusively of working men, assembled on these benches on Monday evenings has been a privilege and a pleasure to all of us.

The peculiar advantages which we have held out to officers of the public service, especially to officers of the army and navy, have not been neglected by the class for whom they were intended. At the same time, it was expected that more use would have been made of them. It is difficult, doubtless, for gentlemen whose duties command so much of their time, to make days and hours suit their convenience. Those who entered our classes, have been among the most diligent of students. The majority have come to us from the East India Company's service, chiefly officers of engineers and medical officers. Much might be done for the advancement of science by naval and military men when on service abroad, and much is being done by them every day as the transactions of learned societies can amply testify. An occasional course of study in one or more of the sciences taught here would enable many a soldier and sailor to occupy vacant hours with pleasure and advantage, and possibly with benefit to the general advancement of knowledge. During the time when I had the

honor of assisting on board one of Her Majesty's surveying ships, I witnessed the happiness and profit that resulted from the pleasure taken by a corps of naval officers in scientific pursuits.

It was supposed that opportunities for scientific instruction such as are here afforded would have been appreciated by intelligent persons among the middle and higher ranks, having time at command. With the exception of a chosen few, the anticipation has proved fallacious. Possibly the occult science of table-turning, which in these days seems to occupy the place filled by astrology in days of yore, has too seriously occupied their thoughts to permit of chemical, physical, geological, or biological studies. In London there are several institutions of high character, that offer, at reasonable cost, scientific instruction to the so-called "educated" classes; yet if the numbers of all, young and old, who avail themselves of the chances that are placed within their reach were to be summed up, scanty indeed would the proportion appear who appreciate, as compared with the vast majority who neglect, the opportunity. Need we wonder then at the success of popular follies and absurdities among persons to whom, if we applied the epithet "unenlightened," we should give mortal offense? There is, indeed, no stronger argument in favor of the State taking the initiative in scientific instruction of the kind given here, than the fact, that the classes of the people who cannot afford to pay high fees, or come to learn during the hours of the day, are anxious and thankful for it; whilst those who ought to support deserving institutions of private foundation have yet to be imbued with a taste for natural knowledge, before they will do that which should be at once a duty and a pleasure.

This year our resources, though still too limited, have been considerably extended, and an important and indispensable want supplied, through the institution of a lectureship on Applied Mechanics. It is with feelings of exultation that I venture to allude to the manner in which this new post has been filled. The accession to our corps of so eminent a philosopher as Professor Willis is an honor deeply appreciated by all of us. In him we feel that we have acquired a new source of strength, whose value cannot be too highly reckoned. We feel, too, that in the world of science, and in the world of mechanical industry, the approbation of this appointment is universal.

In the presence of Dr. Hofmann, who though appointed to the lectureship on Chemistry and charge of the Laboratory, since the conclusion of last session, has sat with us and served amongst us for some time, I will not—I need not—enter on any eulogium of his distinguished merits. To have secured the services of one of the most eminent of European chemists, for the post until lately so ably filled by Dr. Lyon Playfair, is as great a satisfaction to ourselves, as it will be a guarantee of good work to the public.

His predecessor has left us for a post of heavy responsibility and inestimable importance,—one on the conduct of which the success of government institutions for scientific education will in a great measure depend. He has left us with our warmest wishes for his success, and our firmest confidence in his ability, energy, earnestness, and truthfulness. But though no longer holding a professorial post here, we retain the benefit of his advice and counsel, since he still remains connected with our institution, and sits with us as a member of our Educational Committee.

We commence the session—so far as the class of students of most consequence, viz., the matriculated class, is concerned—under peculiarly favorable auspices. The number of entries is greater at this early stage of the courses than during either of the former years. Considering how difficult it is in our country for any establishment on a new plan to make way, this evidence of progress may be taken as a fair subject for congratulation.

The object of the Museum in which we are now assembled is mainly the illustration of the mineral constitution and products of the British islands, and to some extent, of the British colonies. This purpose, whether we consider the great benefit derived from mineral wealth by our nation at large, the vast capital invested in the search after and application of mineral resources, or the light thrown upon science under its nobler and less profitable forms, cannot but be esteemed a worthy one. To carry it out effectively would require more than double the space here assigned to it, and powers of speedy and comprehensive action such as are not usually conferred upon the managers of State institutions. The purpose of the place in some of its branches is more or less fully presented, but in others is barely sketched or rather indicated. The applications of mineral products to the various useful and ornamental arts are so numerous, that, except in a few principal instances, it would be folly to attempt their illustration within our confined boundaries. Consequently, in a purely industrial direction our display is sketchy and partial. That a collection fully and judiciously illustrating the arts that spring from the world of minerals, treated with equal regard to their present extension and past history, to their excellencies, capabilities, and defects, would be in the highest degree instructive and beneficial, if employed in the illustration of well-devised courses of instruction, there cannot be a doubt. If ever such a collection be formed, this institution may fairly claim the credit of its paternity.

In one of its departments this Museum aims at more amplitude; and even proceeding at our present somewhat tardy pace—inevitably so, as we are situated,—must in the end attain, or at least nearly approach, completeness. I allude to that devoted to the illustration of the geological structure of the British Islands. You are aware that we are here an establishment in intimate connex-

ion with, and many of us officers of, the Geological Survey of the United Kingdom. Perhaps the most distinctive feature of this Museum is, that it is the visible evidence of the bearings and progress of that survey. When the officers of the Royal Engineers have performed their duty as topographers, and given to the public the admirable and invaluable maps issued by the Ordnance, then the members of the corps of Government geologists go over the ground anew with the distinct and important office of delineating its mineral structure. On electrotype casts of the original Ordnance plates, the new lines traced by the officers in charge of the geology are laid down, and the new map so constituted is issued to the public at an expense corresponding to the cost of fresh work and coloring. My colleagues in the field to whom these labors are assigned are engaged in a laborious task, requiring judgment, skill, training, and high scientific acquirements. Theirs, no more than ours, in this museum and school, are not mere duties of routine, office, clerkship, or limited hours. There is no off-duty; the head must work whilst the eyes are open if our task is to be well and thoroughly done.

Whilst the collections here displayed are mainly confined to the mineral products of the British islands, there is one department in this building, represented at present by three or four wall-cases, that I cannot refer to without the deepest interest, insignificant though it may now seem. I allude to that of Colonial Geology. The idea of it is to exhibit the mineral products of each of our colonies separately, the evidences of their geological constitution, and the indications of their mineral wealth. Such a display would be more than a curious and interesting illustration of the products of those countries for the benefit of persons at home. It would be a source of instruction of the most vivid kind to all thoughtful men intending to emigrate,—and most emigrants are thoughtful, at least before they go. Over and over again, when working at the arrangement of the cabinets in our galleries, I have been addressed by intelligent persons of this class who have come here in the hope of meeting with a collection of the kind I have mentioned, and of passing some time in the study of it. With feelings akin to shame I have shown them our shabby though not worthless display, and endeavored to make it the text of conversation and advice. Surely it would be worthy of a great empire like ours to possess, in the metropolis of all its world-strewn states, some sufficient illustration of their structure and productions. I speak not merely of their mineral productions, which are all that we can aim at here, but of their works of art and industry, their natural productions of all kinds, and illustrations of their history and of their ethnology. It is true that many of these are embodied in general collections, and form an essential part of systematically arranged cabinets. But what we

require is to see them distinctly grouped with regard to their geography; so that, for example, the emigrant proceeding to Australia might come and learn before he departed, and the officer ordered on duty to India or the West Indies might acquire an acquaintance with the structure and products of those countries that would enable him when there to occupy his spare time in research useful to himself and beneficial to his country. All that is required for carrying out such a collection is space. Contributors anxious and able to assist would be found in numbers. Those who have derived some benefit and knowledge from their studies in the Museum before leaving, would when abroad add judiciously and gratefully to its contents. Indeed there are at present extensive and valuable collections of colonial specimens lying useless, packed in boxes, that might be had for the asking, provided it could be shown that there was a proper place in which to arrange them for the public benefit.

Museums, of themselves alone, are powerless to educate. But they can instruct the educated, and excite a desire for knowledge in the ignorant. The laborer who spends his holiday in a walk through the British Museum, cannot fail to come away with a strong and reverential sense of the extent of knowledge possessed by his fellow-men. It is not the objects themselves that he sees there and wonders at, that make the impression, so much as the order and evident science which he cannot but recognize in the manner in which they are grouped and arranged. He learns that there is a meaning and value in every object however insignificant, and that there is a way of looking at things common and rare distinct from the regarding of them as useless, useful, or curious,—the three terms of classification in favor with the ignorant. He goes home and thinks over it; and when a holiday in summer or a Sunday's afternoon in spring tempts him with his wife and little ones to walk into the fields, he finds that he has acquired a new interest in the stones, in the flowers, in the creatures of all kinds that throng around him. He can look at them with an inquiring pleasure, and talk of them to his children with a tale about things like them that he had seen ranged in order in the Museum. He has gained a new sense,—a thirst for natural knowledge, one promising to quench the thirst for beer and vicious excitement that tortured him of old. If his intellectual capacity be limited and ordinary, he will become a better citizen and happier man; if, in his brain there be dormant power, it may waken up to make him a Watt, a Stephenson, or a Miller.

It is not the ignorant only who may benefit in the way just indicated. The so-called educated are as likely to gain by a visit to a Museum, where their least cultivated faculties, those of observation, may be healthily stimulated and brought into action. The great defect of our systems of education is the neglect

in *educating* the observing powers,—a very distinct matter, be it noted, from scientific or industrial *instruction*. It is necessary to say this, since the confounding of the two is evident in many of the documents that have been published of late on these very important subjects. Many persons seem to fancy that the elements that should constitute a sound and manly education are antagonistic,—that the cultivation of taste through purely literary studies and of reasoning through logic and mathematics, one or both, is opposed to the training in the equally important matter of observation through those sciences that are descriptive and experimental. Surely this is an error; partizanship of the one or other method or rather department of mental training, to the exclusion of the rest, is a narrow-minded and cramping view from whatsoever point it be taken. Equal development and strengthening of all are required for the constitution of the complete mind, and it is full time that we should begin to do now what we ought to have done long ago. Through the teaching of some of the sections of natural history and chemistry,—the former for observations of forms, the latter of phenomena,—I cannot but think the end in view might be gained, even keeping out of sight altogether, if the teacher holds it best to do so, what are called practical applications. For this branch of education museums are the best text-books; but, in order that they should be effectively studied, require to be explained by competent teachers. Herein at present lies the main difficulty concerning the introduction of the science of observation into courses of ordinary education. A grade of teachers who should be able and willing to carry science into schools for youth has hardly yet appeared. Hitherto there have been few opportunities for their normal instruction. Now, in a great measure, this defect may be considered as removed; and in the metropolitan schools of science and art connected with the Board of Trade there are ample opportunities afforded for the acquirement of scientific knowledge in the required direction by persons who purpose to become educators.

In their instructional aspect, considered apart from their educational applications, the value of Museums must in a great measure depend on the perfection of their arrangement and the leading ideas regulating the classification of their contents. The educated youth ought, in a well-arranged museum, to be able to instruct himself in the studies of which its contents are illustrations, with facility and advantage. On the officers in charge of the institution there consequently falls a serious responsibility. It is not sufficient that they should be well versed in the department of science, antiquities, or art committed to their charge. They may be prodigies of learning, and yet utterly unfitted for their posts. They must be men mindful of the main end and purpose in view, and of the best way of communicating knowledge according to

its kind, not merely to those who are already men of science, historians, or connoisseurs, but equally to those who as yet ignorant desire to learn, or in whom it is desirable that a thirst for learning should be incited. Unfortunately museums and public collections of all kinds are too often regarded by their curators in their scientific aspect only,—as subservient to the advancement of knowledge through the medium of men of science or learning, and consequently as principally intended for the use of very few persons. This is not the main purpose for which the public money is spent on museums, though one of the very highest of their uses, and in the end of national consequence, since the surest measure of national advancement is the increase and diffusion of scientific and literary pursuits of a high grade. One of the signs of a spread of sound knowledge and intellectual tastes in a country is the abundant production of purely monographic works by its philosophers, and the evidence of their appreciation by the general mass of readers, as indicated by the facility with which they find publishers.

Very few museums present much of an industrial aspect, valuable, interesting, and popular as any arrangement or display of their contents under this point of view must evidently be. The noble invention of the Great Exhibition, a glory to the end of time around the name of one of the most enlightened princes, proved to all men the high and national interest inherent in industrial collections. It is indeed strange that amongst a people so essentially industrial in their habits, occupations, and modes of thought as the English nation, no great and comprehensive collections illustrative of their agriculture, manufactures, machinery, and sources of trade should have been formed long ago. This defect in our institutions is, however, rapidly in the course of being removed; and I need not dwell upon the value of a kind of museum, of which all sensible men now understand the importance.

It has long been a subject of discussion, in what manner and to what extent can instruction by means of lectures and public teaching be advantageously associated with public collections. There are those who are opposed to such a course, holding that museums should stand on their own exclusive merits, and be mainly places of personal study and consultation. This, however, is the contemplation of them under their scientific aspect only; and though it may fairly be maintained, that a great central collection, such as the British Museum, may be rendered most serviceable by this course of action, holding that magnificent establishment as a general index for science, and, as it were, Encyclopedia of reference,—I feel convinced, after a long and earnest consideration of the question for many years, that unless connected with systems of public teaching, museums in most instances are

of little use to the people. The most useful museums are those which are made accessory to professorial instruction, and there are many such in the country, but almost all confined to purposes of professional education, and not adapted for or open to the general public. The museums of our Universities and Colleges are, for the most part, utilized in this way, but the advantages derived from them are confined to a very limited class of persons. In this Institution, an endeavor has been made to render its contents subservient to the cause of education and instruction; and the course which is here taken may be imitated with advantage in the provinces, where there are not unfrequently collections of considerable extent turned to small account for the benefit of the residents, a large proportion of whom in many instances are ignorant of their very existence. Yet it is to the development of the provincial museums, that I believe we must look in the future for the extension of intellectual pursuits throughout the land, and therefore I venture to say a few words respecting what they are and what they should be.

When a naturalist goes from one country into another, his first inquiry is for local collections. He is anxious to see authentic and full cabinets of the productions of the region he is visiting. He wishes, moreover, if possible, to study them apart—not mingled up with general or miscellaneous collections,—and distinctly arranged with special reference to the region they illustrate. For all that concerns the whole world or the general affinities of objects he seeks the greatest national collections, such as the British Museum, the Jardin des Plantes, the Royal Musenms at Berlin and Vienna. But that which relates to the particular country he is exploring, he expects to find either in a special department of the national museum, or in some separate establishment, the purpose of which is, in a scientific sense, patriotic and limited. So also with the students of history and antiquities; they are often disappointed, and in the end find what they require here and there, bit by bit, in the cabinets of private individuals. In like manner, when the inquirer goes from one province to another, from one county to another, he seeks first for local collections. In almost every town of any size or consequence he finds a public museum, but how often does he find any part of that museum devoted to the illustration of the productions of the district? The very feature which of all others would give interest and value to the collection, which would render it most useful for teaching purposes, has in most instances been omitted, or so treated as to be altogether useless.

Unfortunately not a few country museums are little better than raree-shows. They contain an incongruous accumulation of things curious or supposed to be curious, heaped together in disorderly piles, or neatly spread out with ingenious disregard of their relations. The only label attached to nine specimens out of ten is,

"Presented by Mr. or Mrs. So-and-so;" the object of the presentation having been either to cherish a glow of generous self-satisfaction in the bosom of the donor, or to get rid—under the semblance of doing a good action—of rubbish that had once been prized, but latterly had stood in the way. Curiosities from the South Seas, relics worthless in themselves, deriving their interest from association with persons or localities, a few badly stuffed quadrupeds, rather more birds, a stuffed snake, a skinned alligator, part of an Egyptian mummy, Indian gods, a case or two of shells, the bivalves usually single and the univalves decorticated, a sea urchin without its spines, a few common corals, the fruit of a double cocoa-nut, some mixed antiquities, partly local, partly Etruscan, partly Roman and Egyptian, and a case of minerals and miscellaneous fossils,—such is the inventory and about the scientific order of their contents. I have a vivid remembrance of going through the Cheetham collection at Manchester, and hearing the explanation of its contents by one of the boys on the foundation, when I was of small size myself. The peculiar classification that mystified sightseers thirty years ago is in too many instances still maintained.

There are, however, admirable exceptions to this censure. There are local collections arranged with skill and judgment in several of our county towns, and which at a glance tell us of the neighborhood and activity of a few guiding and enlightened men of science. It would be invidious to cite examples, and yet the principles, in each case distinct, adopted in the arrangement of those of Ipswich and Belfast ought especially to be noticed. In the former, thanks to the advice and activity of Professor Henslow, the specimens of various kinds, whether antiquarian, natural history, or industrial, are so arranged as to convey distinct notions of principles, practice, or history. In the Belfast Museum the eminent naturalists and antiquarians who have given celebrity to their town have made its contents at a glance explanatory of the geology, zoology, botany, and ancient history of the locality and neighboring province. The museums of Manchester, York, Scarborough and Newcastle might be cited as highly commendable likewise, thanks to the science and ability of the eminent men connected with them, or who have taken an interest in their formation. It so happens, however, that the value and excellence of almost every provincial museum depend upon the energy and earnestness of one, two, or three individuals, after whose death or retirement there invariably comes a period of decline and decay. Now this should not be, and would not be were the facilities for scientific and literary instruction in the provinces greater than they are. In very few instances do we find the collections freely open to the public. In most cases they are unassisted by local or corporate funds, and dependent entirely upon the subscriptions of private individuals. Indeed, any attempt to favor the establish-

ment of public museums and libraries through the application of local funds is opposed with a horrible vigor more worthy of a corporation among the Cannibal Islands than within the British Empire. The governing bodies of too many of our towns include no small proportion of advocates of unintellectual darkness. It is not the interest of the public but that of the publican which sways, when a councillor wiser than the rest proposes in vain to inform his fellow-citizens through the agency of free museums, libraries and gardens. This may seem a harsh and possibly a rash censure, but I speak deliberately and with knowledge of examples. And yet, alas, the direful sway of distilleries and breweries may be excused, when we learn that in some, be it hoped few instances, the proposition to establish public libraries by means of a small local rating has been opposed by the members of local so-called philosophical institutions, on the plea that having got what they wanted in this way for themselves they did not choose to pay a tax for the extension of these advantages to their less fortunate fellow-citizens.

In every museum of natural history, and probably in those devoted to other objects, there gradually, often rapidly, accumulates a store of duplicates that if displayed in the collection render it more difficult to be studied than if they were away altogether, occupying as they do valuable space and impeding the understanding of the relations and sequence of the objects classified. If, as is sometimes the case, they are rejected from the collection and stowed away in boxes or cellars, they are still in the way; for cellarage and storage—as we know here, from the want of them, to our detriment,—are indispensable for the proper conducting of the arrangements of museums. Yet out of these duplicates, more or less perfect sets of specimens might be made up, of very high value for purposes of instruction. A well-organized system of mutual interchange and assistance would be one of the most efficient means of making museums generally valuable aids to education. Much money, when money is at the command of curators or committees, is spent in purchasing what might be obtained for asking or through exchange. Some objects of great scientific interest, but equally costly, might be purchased by one establishment only, and made fully as useful, instead of being bought in duplicate by two or more contiguous institutions. The larger institutions might supply the smaller; and out of the national stores, numerous examples—to them almost worthless, but to provincial establishments highly valuable—might be contributed with facility and greatly to the public benefit.

It is in this way, viz. by the contribution of authenticated and instructive specimens, that the museums supported by the State can most legitimately assist those established from local resources in the provinces: the scientific arrangements of the latter might also be faciltated through the aid of the officers attached to Gov-

erment institutions. Money grants would do in many cases more harm than good, destructive as they are of a spirit of self-reliance, and apt to induce a looseness of expenditure and habits of extravagance.

At the same time, every shilling granted judiciously by the State for purposes of education and instruction, for the promotion of schools, libraries, and museums, is a seed that will in the end generate a rich crop of good citizens. Out of sound knowledge spring charity, loyalty, and patriotism—the love of our neighbors, the love of just authority, and the love of our country's good. In proportion as these virtues flourish, the weeds of idleness, viciousness, and crime perish. Out of sound knowledge will arise in time civilization and peace. At present it is folly and self-conceit in nations to claim to be civilized, otherwise than as contrasted with savage barbarity. The admiration of physical prowess, the honoring of tinsel and pomp, the glorification of martial renown, are yet far too deeply inrooted in the spirit of the most cultivated nations to permit of the noble epithet "civilized," being appended to their names. The nobility of industry in all its grades,—first soul work, the labor of genius—then head-work, the labor of talent,—then hand-work, the honest labor of the body striving in the cause of peace—must be honored by state and people, before either can with truthfulness claim to be civilized. We are at best as yet but enlightened barbarians. Think how all Europe and half Asia have stood for months, and are even now standing, on the verge of foul and barbarous war; how Christian nations have girded on their armor, and, with mutual distrust and well-grounded suspicion, have stood with hand on sword-hilt ready to guard or to strike; think of what is worse, of the crime and ignorance that fester in the byways of Christian cities, and then boast of civilization if you can. The arts, the sciences, taste, literature, skill, and industry seem to have thriven among us in spite of ourselves—to have come among mankind like good spirits, and by main force to have established themselves on earth. They struggle with us and conquer us for our welfare, but are not yet our rulers. Sent from Heaven, aided by the few, not by the many, they have made firm their footing. If the monarchs and presidents of the states of the earth knew wherein the best interest of themselves and their people lay, it is in these intellectual invaders they would confide. The cost of armaments and the keep of criminals would cease in time unproductively to drain their treasuries. But ambition and strife are sturdy demons yet, and the educator, who dreams of their enchainment, and anticipates the speedy approach of a peaceful millenium, has but a limited acquaintance with the condition of mankind, and the hearts of its governors.

I cannot help hoping that the time will come when every British town even of moderate size will be able to boast of possessing

public institutions for the education and instruction of its adults as well as its youthful and childish population,—when it shall have a well-organized museum, wherein collections of natural bodies shall be displayed, not with regard to show or curiosity, but according to their illustration of the analogies and affinities of organized and unorganized objects, so that the visitor may at a glance learn something of the laws of nature,—wherein the products of the surrounding district, animate and inanimate, shall be scientifically marshalled and their industrial applications carefully and suggestively illustrated,—wherein the memorials of the history of the neighboring province and the races that have peopled it shall be reverently assembled and learnedly yet popularly explained; when each town shall have a library the property of the public and freely open to the well-conducted reader of every class; when its public walks and parks (too many as yet existing only in prospect) shall be made instructors in botany and agriculture; when it shall have a gallery of its own, possibly not boasting of the most famous pictures or statutes, but nevertheless showing good examples of sound art, examples of the history and purpose of design, and, above all, the best specimens to be procured of works of genius by its own natives who have deservedly risen to fame. When that good time comes, true-hearted citizens will decorate their streets and squares with statues and memorials of the wise and worthy men and women who have adorned their province, not merely of kings, statesmen, or warriors, but of philosophers, poets, men of science, physicians, philanthropists and great workmen. How often in travelling through our beautiful country do we not feel ashamed of its towns and cities, when we seek for their ornaments and the records of their true glories and find none? How ugly is the comparison that forces itself upon our minds between the conduct of our countrymen in this respect and that of the citizens of continental towns? A traveller need not go far through the streets of most foreign cities without seeing statues or trophies of honor, serving at once as decorations and as grateful records of the illustrious men they have produced,—reminding the old of a glorious past, and inciting by example the young to add to the fame of their native soil.

My picture may seem a dream; but I have faith sufficient in England and Englishmen to believe that in the course of time it will come to pass. Had the foresight of the present crossed the imagination of an ancient Briton, he might have hoped for its realization in another world, scarcely in this. But a simple belief in the probability of State and people advancing in intellectual aims and true civilization, and working them out through the length and breadth of the land, is essentially too wholesome and compatible with the progress of Christianized human nature, not to find an embodiment in a coming reality.

Art. XXXVII.—*On the Cause of the Aurora Borealis;* by Prof. A. de la Rive.*

When in June 1836, I published in the Bibliothèque Universelle a note on the origin of hail and atmospheric electricity, I already foresaw that the same cause would explain the aurora borealis, and the irregular and diurnal variations of the magnetic needle. As I had not then seen an aurora, I withheld at that time this application of the principles. Since then I have witnessed two fine auroras, and the appearances observed, especially during that of November 17, 1848, have confirmed my view of the nature of the phenomena, while they also accord with the observations of others, especially with those of Hansteen, Bravais and Lottin, and also with the many interesting details in Humboldt's Cosmos. My subsequent electrical experiments throw additional light on the origin of the aurora.

This last statement indicates that I regard the cause as electrical. This view has often been presented before, and was brought forward by Arago at the time of Œrsted's discovery. Yet no one, to my knowledge, has explained the mode of action and production of the electricity, or the attendant phenomena resulting from this cause.

Without going into any historical details, I will briefly describe the Aurora Borealis itself and its effects, and then pass to my own theory, the accordance of which with facts I shall endeavor to point out.

1. *Description of the Aurora and its accompanying effects.*

I cite the following details principally from the Cosmos. They are derived mostly from the descriptions of Hansteen, Bravais, Lottin, and other travellers, who have been in favorable places for observing the aurora. The learned author of Cosmos has grouped the facts with great skill, presenting in an admirable manner the prominent points, and seems with scientific tact to reach towards the true theory of the phenomena which he describes.

An aurora borealis is always preceded by the formation in the horizon of a kind of nebulous veil, which rises slowly to a height of four to six or eight, or even ten degrees about the magnetic meridian; the sky though before pure, becomes darkened, and over this obscure segment, whose color varies from brown to violet, the stars are seen as through a thick haze. An arc of light, first white, and afterwards yellow, borders the dark segment. Sometimes this luminous arc is agitated for hours by a

* Mem. Soc. de Phys. et Hist. Nat. de Genève, xiii, and Bib. Univ., xxiv, 337, Dec. 1853.

sort of effervescence, and a constant change of form, before it rises into the rays or columns of light which mount to the zenith. The more intense the emission of the polar light, the brighter are the colors that appear, which from violet and bluish white pass by intermediate shades to green and purplish red—just as electric sparks are colored only when the tension is strong, and the explosion violent. Sometimes the columns of light proceeding from the luminous arc are mixed with blackish or smoky columns; sometimes they rise simultaneously from different points of the horizon; or they may unite in a sea of flames of indescribable magnificence, the form and brilliancy of which are in incessant change. The motion gives greater visibility to the phenomenon. Around the spot in the heavens towards which the dipping needle points, the rays appear to cluster and form a corona. Rarely the aurora continues till the corona is on all sides complete, and when this happens, it announces that the end of the exhibition is near at hand. The rays then become feebler, shorter, and less bright in their colors. Soon, only large nebulous motionless spots, of a pale or ashy tint, are seen over the celestial vault; and finally, traces of the dark segment in the northern horizon, where the appearances began, alone remain.

The connection between the polar light and a certain kind of cloud is recognized by all observers, who affirm, that *the polar light sends forth its brightest columns when the upper regions of the air contain masses of cirro-stratus clouds of great tenuity, which tend to form a corona around the light.* Sometimes the clouds are grouped and arranged like the auroral columns; and in this case they appear to disturb the magnetic needle. After a brilliant aurora, the trains of clouds in the morning have sometimes been found to indicate the positions of as many luminous columns during the night.

The absolute height of the aurora has been variously estimated. For a long time it was supposed that it might be ascertained by the observations of distant observers on the corona: but it is now well known that the corona is only an effect of perspective, due to the apparent convergence of rays which are parallel to the dipping needle; so that each sees his own corona, as each his own rainbow. Moreover the aspect of the phenomenon depends on the position of the observer. The seat of the aurora is in the upper regions of the atmosphere; but sometimes it appears to be produced within less elevated regions, where clouds are formed. Such observations as those of Capt. Franklin appear to establish the latter conclusion, who saw an aurora which lighted up the under surface of the clouds, whilst Mr. Kendall, two to three miles distant, saw no light whatever, although awake and constantly observing the sky. Captain Parry also as-

serts his seeing an aurora depicted on the flank of a mountain: and it is said that a luminous arc has been seen on the surface even of the sea, around the magnetic pole.

Mairan and Dalton believed the aurora borealis to be cosmical, and not atmospheric. But Biot, who had an opportunity of observing the aurora at the Shetland Isles in 1817, proved it to be an atmospheric phenomenon, from finding that it did not partake of the movement of the stars from west to east, and consequently moved with the earth's rotation. Since then, nearly all observers have come to the same conclusion; and in particular MM. Lottin and Bravais, who have observed more than 143 auroras, and given detailed descriptions of them.

It is therefore quite certain that the aurora is not extra-atmospheric. To the evidence from its appearances, we may also add the crackling noise sometimes affirmed to be heard by the inhabitants in the far north, and the sulphurous odor which also has been observed. And, in fine, if the phenomenon is wholly beyond our planet, why should it be located about the polar regions? M. de Tessan, in the voyage of the Venus around the world, saw a fine aurora australis, which he describes with care. It was 14° in height, and the centre of the arc was in the magnetic meridian. He heard no sounds connected with it, which he attributes to its distance: but he mentions that M. Verdier, a French naval officer, on the night of Oct. 13th, 1819, while on the coast of New Holland, heard distinctly a kind of crepitation, during a brilliant aurora. All the details mentioned by M. de Tessan prove the exactness of the observations.

As concomitant effects of the aurora, we have mentioned the crackling sound, and the sulphurous odor. M. Matteucci has also observed during the appearance of a late aurora, satisfactory evidence of positive electricity in the air. But of all the phenomena, those which are of most invariable occurrence are the magnetic. The magnetic needle undergoes perturbations, either to the west or east, and usually the latter. These disturbances vary in intensity, but never fail of taking place; and they are at times manifested in places where no aurora is seen. This coincidence of magnetic disturbance with the aurora, shown by Arago to be without exception, from many years of observation, enabled this philosopher to tell, while in the basement of the Paris Observatory, when there was an aurora in our hemisphere. M. Matteucci has observed this magnetic influence under a new form. During the aurora of Nov. 17, 1848, the armatures of soft iron used with the Electric Telegraph between Florence and Pisa remained attached to their electro-magnets as if strongly magnetised, although the apparatus was not in action, and the batteries out of use.

M. de Tessan cites an observation made in 1818, by M. Baral, another French naval officer, on the same coasts of New Holland, who found that he had been making a wrong course from following his needle; there had been no storm, and the compass had not been touched. But on the evening of the same day, there was a brilliant aurora, and to this he attributes the deviation—a conclusion which could not have been dictated by theory, since at the time (in 1818) the relations between electricity and magnetism were not known.

The intimate connection between the aurora and terrestrial magnetism, has led Humboldt to designate as a *magnetic storm* a succession of disturbances of equilibrium in the magnetic forces of the earth. The presence of this storm is indicated by the oscillations of the magnetic needle, and afterwards, by the aurora, of which the oscillations are precursors, and which also put an end to the storm, just as the lightning in an ordinary electric storm announces that the equilibrium, before disturbed, is again established in the normal distribution of the electricity. Humboldt finds proof, amounting to experimental certainty, in the discovery of Faraday, who produced light by the action of magnetic forces alone, that the earth, by virtue of its magnetism, has the property of emitting light quite distinct from that which is afforded by the sun.

While recognising the truth of the analogy which Humboldt here traces out, we should recollect, that it is not of itself, but because it produces electric currents, that magnetism gives out light; the light is purely electrical in origin. Magnetism produces luminous phenomena only because it can disengage electricity, and it is probably in this point of view that Humboldt says in a general way, that it is a source of light.

It is hence in electricity, and in the influence which this agent in a state of motion, and magnetism, mutually exert, that we must look for the cause of the aurora borealis. This is the view which I would sustain, and to the force of my demonstration, I propose to bring some direct experiments, as well as the results of numerous observations through past years.

2. *Proposed Theory.*

The atmosphere in its normal state is constantly charged with a considerable quantity of positive electricity, which increases as we ascend, starting at the earth's surface where it is zero.

I will not inquire into the origin of this electricity: what is certain is that its production is connected with the action of the sun, since its intensity is subject to diurnal variations. It may be a question whether the sun acts directly, either through its light or its heat, on the constituents of our atmosphere, and so produces the electricity; or whether it is an indirect effect of the

solar rays causing evaporation from the waters of the seas, or the vegetation of the land. It is probable that both causes act: yet I am inclined to regard the first as most general and most constant. But this is of little importance here: the fact of the constant charge of positive electricity in the atmosphere, and of negative electricity in the earth, is abundantly proved, and this is sufficient for our explanations.

This constant production of the two electricities must necessarily be attended by a recomposition or neutralisation; otherwise the contrary electric states would acquire an infinite tension, which is contrary to observation. This recomposition or neutralisation takes place in two ways, one irregular and accidental, the other normal and constant.

The first method is exhibited under various forms. Generally it is the simple humidity of the air, or the fall of rain or snow, which causes the neutralisation. At other times, it is the thunder-bolt, which exhibits in an energetic manner the tendency to union in the two accumulated electricities, one in the air, the other in the ground. The winds in certain cases, by mixing the air from the earth's surface which is negative like the earth, with the positive air of a region more elevated, leads to a neutralisation of the two electricities, causing either storms or an exhibition of heat lightning. In winter, the air being constantly more saturated with moisture, the direct neutralisation is effected through the aqueous vapors and there are therefore fewer great disturbances and consequently fewer storms; and at the same time, as Arago has remarked, considering the number of storms, the lightning strikes the earth more frequently in winter than in summer.

In general, the influence of the hygrometric state of the air on the manifestations of atmospheric electricity is almost as great as that of the cause itself which produces this electricity; for this influence makes itself felt both in the production of the accidental phenomena just enumerated, and in the indications of the electrometer by which we ascertain the normal electric state of the air for the hours of the day, and days of the year. Hence it is difficult to deduce from these observations even the intensity of the atmospheric electricity for any given moment, seeing that it is impossible to separate this original intensity from the degree more or less decided which the electric registers may manifest.

Let us now pass to the second mode of neutralisation of the two electricities, which I regard as normal and regular.

The positive electricity, with which the upper beds of the atmosphere are charged, will traverse them freely, because of their high state of rarefaction. But in the polar region, where the intense cold constantly condenses the aqueous vapors, it finds a

portion of the atmosphere saturated with humidity, giving rise to mists; and by this means it may easily pass to the earth and combine with the negative electricity with which the earth itself is charged. It consequently results that there are constant currents of positive electricity rising from different points of the earth's surface into the upper regions of the atmosphere, which pass towards the poles, and then return beneath the earth's surface towards each of the points whence they have started. The currents of the northern hemisphere should go to the north pole, and those of the southern, to the south pole. In the equatorial regions, the position of the sun will determine the dividing line between the two systems. We may add that the experiments made with the electric telegraph have demonstrated that the terrestrial globe is an almost perfect conductor of electricity, compensating by its mass, for what it wants in the conductibility of the materials which constitute it. Thus the existence of the currents, whose course I have traced, rests on well established principles, with a foundation of simple experiment.

But more than this: their existence is demonstrated by facts long studied and established,—those pertaining to the diurnal variation of the magnetic needle.

I do not examine here into the origin of the earth's magnetism, a subject to which I shall have occasion to return in another work; for the present, I only say that I do not regard the disturbing causes of the direction of the magnetic needle as of the same nature with those which determine this direction. I content myself now with regarding the earth as a large magnet having its two poles; and I study only the causes that modify the direction which, in this quality of a magnet, it tends to impress on the magnetic needle. These causes are the electric currents, whose existence I have just shown; they well explain the diurnal variations. These variations, in fact, consist in this, that in our hemisphere, the north pole of the needle moves to the west, during the morning until $1\frac{1}{2}^h$ P. M., and then returns to the east during the rest of the day, to remain stationary during the night. But this deviation is precisely that which should be occasioned by currents passing along the surface of the globe from the north pole to the equator, augmenting in intensity with the heat of the day and diminishing as it decreases. The diurnal variation is at its maximum (13′ to 16′) in those months in which the sun is longest above the horizon, May, June, July, August. It is at its minimum (4′ to 5′) during the winter months. The variation is greater as we pass from the equator towards the pole; but it is evident, that if the currents, proceeding from different points of the earth's surface heated by the sun, rise in the atmosphere to redescend at the polar regions, and thus traversing the globe, reach their point of departure, the nearer the needle to the mag-

netic pole, the greater the number of currents that will act upon it: near the equator, it will not be subject to any influence from the currents which are formed beyond the region around the needle. In winter these differences are less sensible, because the currents from the equatorial regions are the only ones whose effects will be very decided, on account of the little difference of temperature which exists in this season between the earth's surface and the upper regions of the atmosphere in the temperate and especially the polar zone.

Finally, according to our theory, the same effects should be manifested in the southern hemisphere, only that all is reversed; and this is fully established by the various results of recent observers, including those of Colonel Sabine and a large number of travellers.

I should however acknowledge that there are some anomalies, either in the hours or in the direction of diurnal variation, at certain places, especially at St. Helena and the Cape of Good Hope, anomalies which it is difficult to explain by the theory proposed. But I am convinced that when further examined, they will be found to be due to local and accidental causes, such as the vicinity of the sea, which influences very notably the diurnal variations of temperature, and especially their amplitude and the hours of the maximum and minimum of heat. The question whether there are not places of no variation, proposed by Arago, is of little importance in this connection. The points of the earth's surface without diurnal variation, will be those where the two currents originate, and whence they proceed from the right and left towards the two poles: they are situated in the equatorial regions, but they cannot well be laid down, as their position will vary with the sun, the temperature, the winds, and other disturbing causes.

But I do not dwell on this point, as my object is not to treat of the diurnal motions of the needle. My end is simply to prove from the diurnal variations, the existence of the terrestrial currents. In continuation, we may obtain another proof still more direct, although less general, of the presence of these currents, by making use of the telegraph wires for collecting them. This I have done in England, as has also Mr. Barlow; and M. Baumgartner has performed similar experiments in Germany. In these trials, the currents have in all cases been detected by means of the galvanometer. M. Baumgartner, having introduced a very sensitive galvanometer into the circuit formed by the telegraph wire between Vienna and Prague, which has a length of about 61 miles, obtained the following results when the two extremities of the wire were buried in the earth.

1. The magnetic needle never stood at zero, but was more or less deviated.

2. The deviations were of two kinds, some of large extent, even 50°, others small, varying from 1° to 8°;—the former not common, and changing in direction and intensity, so that no law can be discovered; the latter on the contrary subject to a simple law, and being very regular when the air is dry and the sky serene, but with many anomalies when the weather is cold and rainy.

Mr. Barlow has made numerous observations, and obtained results demonstrating the exactness of the principle which I have laid down. Four main lines starting from Derby, were used in his experiments, two running towards the north and northeast, and two towards the south and southwest. The direction of the currents perceived on the first two lines, was always contrary to that of the currents on the two others, as ought to be the case, on the theory proposed. But the most remarkable fact, is the perfect concordance which these observations have proved to exist between the movement of the needle of the galvanometer placed in the circuit of the telegraph wire and the diurnal variations of the magnetic needle. The diurnal movement of the needle of the galvanometer is subject to disturbances in intensity more or less continued, during storms, and also when the aurora borealis is visible; and so also is this true of the compass needle. There is this difference, that the currents acting on the latter, circulating beneath the earth's surface, should not be subject to disturbances like those which happen to the telegraph wires through the influence of the electrical condition of the atmosphere about them.

The existence then of electric currents circulating beneath the earth's surface appears to us to be well demonstrated; and once proved, it leads necessarily to the conclusion that it is a consequence of the normal and regular reëstablishment of the electric equilibrium between the earth and its atmosphere, which is broken essentially in tropical regions; whilst the electric discharges, more or less intense, which take place between the earth and the air are the accidental and variable means for the reëstablishment of this equilibrium. We may now see how the explanation of the phenomena of the aurora both north and south, flows necessarily from the formation of these electric currents circulating from the equator to the two poles in the upper regions of the atmosphere, and from the two poles to the equator along or beneath the surface of the globe.

As we have said above, the positive electricity with which the atmosphere is charged, especially in the upper regions, is carried towards the two poles either by the greater conductibility of the upper and most rarified strata of the atmosphere, or by the currents of air in the upper regions which move from the equator to the two poles. It is consequently through the vapors which are

constantly condensed in the forming mists in the polar regions that the positive electricity should find its passage into the earth, and also therefore its discharge. This discharge when possessing a certain degree of intensity should be luminous, especially if, as is almost always the case near the poles and sometimes in the upper regions of the atmosphere, it encounters in its course icy particles of extreme minuteness, which form the haze as well as the more elevated clouds.

The formation of lunar halos which generally precede the appearance of an aurora, and the fall of rain or snow which also is often a prelude to it, are a proof of the presence in the atmosphere of these fine needles of ice, and of the part they play in the phenomenon before us.

This attenuated mist, rendered luminous by the transmission of electricity, ought to appear under a regular form, like an illuminated surface of greater or less extent, and more or less broken. It should spread outward from the poles, forming as a first appearance the auroral bank like a veil in the north. The tenuity of this veil is such that the stars may be seen through it, as has been remarked by all observers. MM. Bixio and Barral, in the balloon ascension which they recently made, suddenly found themselves,—although the sky was quite serene and the atmosphere without a cloud—in the midst of a veil or mist, which was perfectly transparent, consisting of a multitude of small icy needles so fine that they were hardly visible. Such are the needles which become luminous by the passage of the electricity, which determine the formation of halos as has been rigorously demonstrated, and produce by condensation the aqueous vapors in their passage through the air towards the earth, the fall of snow or rain, or sometimes under peculiar circumstances, hail.

Now if we inquire what should pass in the portion of the luminous mist nearest to the earth's surface, we shall conclude that the vicinity of the magnetic pole must exert a decided influence on this electrised matter,—for it is in fact a true mobile conductor traversed by an electric current.

In order to obtain a correct idea of this action, I have endeavored to imitate artificially the process of nature, and with this view, I contrived the following experiment.

Into a glass globe, 30 to 40 centimeters in diameter, I introduced through one of its two opposite tubulures, a piece of soft iron wire, about 2 centimeters in diameter, making it to terminate at the inner end very near the centre of the globe, while the other end was exposed out of the globe. The wire was covered through its whole length, excepting its extremities, by a very thick insulating bed formed first of shell-lac, then with a glass tube covered itself with shell-lac, then with a second tube of glass, and finally with a bed of carefully applied wax. The

insulating layer in all was a centimeter thick, giving 4 centimeters for the thickness of the bar thus covered. Within the globe, a ring of copper surrounded the bar and its insulating bed, at the part most distant from the tubulure. This ring was arranged to be put in communication with a source of electricity exterior to that of the bar by means of a metallic wire insulated with care, which passed through the tubulure and ended without in a hook. A stopcock attached to the other tubulure of the globe, was arranged for obtaining a vacuum. When the air within is sufficiently rarified, the hook is connected with the conductor of an electric machine, and the outer extremity of the bar of iron with the soil; by this means the electricity forms within the globe a luminous sheaf, more or less irregular, which passes from the ring, and terminates at the inner extremity of the soft iron. But immediately on placing the outer extremity of the soft iron on the pole of an electro-magnet, the electric light takes a wholly different aspect. Instead of proceeding indifferently from different points of the upper surface of the cylinder of iron, it proceeds from all points in the circumference of this surface, so as to form around it a continuous luminous ring. This is not all: this ring has a movement of rotation around the magnetized cylinder, sometimes in one direction and sometimes in the other, according to the direction of the electric current, and the nature of the magnetisation. Finally, jets of brilliant light are seen to proceed from this luminous circumference, which are distinct from the rest of the mass of light. When the magnetization ceases, the luminous phenomena return to the condition familiar in the experiment, known under the name of the *Electric Egg*.

There is some advantage in using for the experiment here described Armstrong's hydro-electric machine, in which the boiler is made to communicate with the hook which is united by a metallic connection to the ring of copper within the globe, whilst the conductor which receives the vapor is put in connection with the bar of soft iron. Thus we have in the globe an electric current of great intensity which may be changed in direction, by inverting the connections.

3. *Agreement of the theory with the facts.*

We have remarked that all observers agree now in regarding the aurora as an atmospheric phenomenon, and we have cited facts in support of this view. One more fact may be alluded to here which places it beyond doubt; it is from the observations on the aurora borealis published in the History of the Voyage of Captain Franklin. Lieutenant Hood and Dr. Richardson were 55 miles miles apart for the purpose of making simultaneous observations, in order to ascertain the parallax of the phenomenon and consequently its height. The results from three trials place

it alike at a height of 6 to 7 miles. On the 2nd of April, at the most northerly station a brilliant arc was seen 10° above the horizon; at the other station, it was not visible. The 6th of August the aurora was at the zenith at one station, and 9° in height at the other. On the 7th of April it was again in the zenith at the first station, and 9° to 11° in height at the second.

Again, Hansteen, and after him, MM. Lottin and Bravais, were led to believe as a consequence of their observations, that the arc of the aurora is a luminous ring whose different parts are sensibly equidistant from the earth, and which is centered around the magnetic pole so as to cut at a right angle all the magnetic meridians which converge towards this pole. Such a ring is the auroral arch and its *apparent* summit is necessarily in the magnetic meridian of the place. M. Bravais also observes that the arc seems to have a kind of movement of rotation from the west to the east passing by the south. From this description the phenomenon is quite similar to the result of the experiment described above, and the direction of the rotation in the luminous ring is precisely that which ought to take place according to the laws governing the mutual action of currents, if it be the positive electricity which passes from the atmosphere to the surface of the earth, thence to penetrate about the north magnetic pole, reunite with the negative electricity, and thus constitute the current.

The diameter of the luminous ring will be greater, as the magnetic pole is more distant from the earth's surface, since this pole ought to be found in the intersection of the plane of the ring with the axis of the terrestrial globe.

It hence results that each observer sees the summit of the auroral arc in his own magnetic meridian; and hence only those on the same magnetic meridian see the same summit, and can take simultaneous observations for ascertaining the height.

If the summit of the arc pass the zenith of the observer, he is surrounded on all sides by the matter of the aurora, or the auroral influences which proceed from the earth, and then, if at all, the crackling sound which has been alluded to should be heard. If it does not reach the zenith, the observer is then outside of the region; and the aurora is more or less distant according to its altitude. The noise may be produced by the action of a powerful magnetic pole on luminous electric jets very near this pole, as I have proved by experiment; I have succeeded in producing a similar sound by bringing a piece of iron, strongly magnetised, to the luminous arch formed between the poles of a voltaic battery.

As to the sulphurous odor, it proceeds like that which accompanies lightning, from the conversion of the oxygen of the air into ozone by electric discharges.

The light of the aurora is not polarized, as was remarked by Biot in 1817, from his observations at the Shetland Islands. This

negative result is confirmed by Mr. Macquorn Rankine, who has shown that this absence of polarisation is not due to the feebleness of the light, since this same light viewed after reflection from water is found to be polarised by this reflection. The most careful study and experiment have found no trace of polarisation in electric light, whether the discharges be made in the air or in a vacuum. This is a new proof of the identity of these two kinds of phenomena.

Finally, we discover in the resemblance between auroral appearances and certain clouds, as well as the disturbances of the magnetic needle, a further important confirmation of our theory.

The observations of Dr. Richardson already mentioned, which show that the aurora exists at moderate elevations, also indicate that it is often connected with the formation of different kinds of *cirro-stratus* clouds. Lieutenant Hood, in speaking of the luminous bands or columns of the aurora, says that he is convinced that they are carried by the wind, because they retain exactly their relative situation, which is not the case when the luminous matter moves in the air by its own direct action. Finally, the coëxistence of the aurora with small ice needles in the atmosphere, such as exist in elevated clouds, is shown by Captain Richardson, who having seen at a temperature near $-32°$ C. ($-35°$ F.) an aurora whose superior arc was near the zenith, remarked that although the sky appeared perfectly serene during the phenomenon, there fell a fine snow hardly perceptible to the eye, though easily observed as it fell on the hand and melted. The same fact had been previously observed in full sunshine, the rays of the sun rendering the floating particles of ice visible.

Observers are agreed with regard to the existence of a stratum or dark segment, which rests in the northern horizon, and appears to be the source of the auroral display. The numerous observations of M. Struve at Dorpat, and those of M. Argelander at Abo confirm this appearance. It is like a veil, which although permitting the light to pass gives the sky a more somber aspect; moreover it is bordered by a luminous arc. The existence of such a dark segment is confirmed by an observation of Gisler, who says that in Sweden, upon the high mountains, the traveller is sometimes suddenly enveloped in a very transparent mist of a grayish white color, verging towards green, which rises from the soil, and is changed into the aurora borealis.

The cirro-cumulus and the mists become luminous when they are traversed by electric discharges sufficiently energetic, provided daylight does not efface the feeble light. They may sometimes be detected in the day: thus Arago establishes most incontestably that Dr. H. Usher was not deceived in a notice published in volume II. of the Memoirs of the Irish Academy, where he describes an aurora seen at mid-day on the 24th of May, 1788.

This observer, during the day after a night in which he had witnessed a brilliant aurora, having observed an oscillation of the stars as seen with his lens, perceived in the sky rays of a white quivering light which rose from all points in the horizon towards the pole of the dipping needle, where they formed a light and whitish corona like that which the most brilliant aurora presents at night. Arago, on consulting old records at the observatory, found that there were considerable magnetic disturbances that day in the magnetic needle kept for showing the diurnal variation, thus proving beyond question that the phenomenon observed by Dr. Usher was a veritable day aurora.

I find also in the account of the voyage of the Venus by M. de Tessan, that M. Cornulier, an intelligent officer in the French Navy, often observed on the coast of New Holland a particular direction in the cirrus clouds during the day, from which he was enabled always to announce a fine aurora australis at night. M. Cornulier, like M. Verdier, was convinced, from a study of the arrangement of the cirrus clouds, that in those regions, auroras occur during nearly every day, and that the variation is only as to their brightness; they are often hid from view by clouds and storms. This remark agrees with the observations made under the direction of Captain Lefroy in Canada, at 13 different stations, and with others, collected by the Smithsonian Institution. It results from all these observations, that the aurora was seen on almost all clear nights, when the moon was not too bright, although not at all the stations. This is especially true during the months when the nights are longest. From October to March, there is scarcely a night without a visible aurora; and they are most brilliant in the month of February. The tables show that auroras were seen during 261 nights in 1850, and 207 in 1851. It is also remarkable and natural, that the auroras should have been seen most frequently in the stations nearest the magnetic pole.

Recurring to the coëxistence of icy particles in the air with the auroras, we find striking proof on this point in the Canada observations. The tables give with exactness the weather before and after the auroras. The aurora was almost always preceded by a fall of rain or snow; it also often happened that a fall of one or the other succeeded the aurora. The appearance of lunar halos, a common prelude to auroras, is a proof of the presence in the atmosphere of these icy particles which make up the network illuminated by the electric current.

But the most important proof of the electrical origin of the aurora is that derived from its action on the magnetic needle. The observations by Arago at the observatory of Paris,* by Fors-

* Ann. de Ch. et de Phys., x. 120; xxx, 423; xxxvi, 398; xxxix, 369; xlii, 351; xlv, 403.

ter, Farquharson, and by all voyagers, establish the following conclusions:—

1. During the day preceding the night on which an aurora appears, the declination of the magnetic needle to the west is always augmented 10, 20 or 30 minutes, or more.

2. On the contrary, at the middle, and at the end of the exhibition, the needle deviates from its normal state to the east.

3. Finally, the needle often undergoes irregular perturbations during an aurora, amounting to several minutes.

It happens ordinarily that the maximum deviation of the needle during the day preceding the night of the aurora, is at noon, or half an hour after noon; and the deviation due to the disturbance may be 5 to 30 minutes or more, beyond that of the days before or following. Sometimes the maximum western deviation is at other hours in the morning, and it is probable that in such cases there is an aurora during the day. Arago cites several cases of this kind. Thus, on the 17th of August, 1828, the declination from 8½h. A. M. till noon was 5′ above the mean of the month for the same hours; and on the same day, at 10h. P. M., Messrs. Coldstream and Foggo perceived feeble traces of an aurora which was probably the end of a day aurora. During the evening the needle was in its ordinary position.

The magnetic observations made in the regions near the pole confirm the influence on the needle. Thus at Reykiuwik (64° 8′ 15″ N.) MM. Lottin and Bravais, having made numerous observations on the diurnal variation of the needle parallel with similar observations at Paris and Cherbourg, were struck with the almost continual disturbance of the needle. They at first attributed it to some movement in the earth: but afterwards, remarking the concordance of their observations with those of M. de Löwenörn made in 1786, 50 years before, they satisfied themselves that the effect was due to auroras invisible to them because of the continued presence of the sun above the horizon. M. Ginge, a Danish Missionary, made observations in 1786, 1787, continued through the 24 hours, which showed that the western declination was ordinarily strongest from 9 to 10 in the evening, and least at 9 to 10 in the morning, a fact which he attributed without hesitation to the aurora. This conclusion is confirmed by the very numerous and excellent observations of MM. Lottin and Bravais.

We thus see, that for a long period observations near the pole have shown that auroras must be more frequent than was supposed, and this is confirmed by the facts observed in Canada and the United States.

We therefore conclude, that the production of auroras, northern and southern, is the normal mode of neutralising the positive electricity of the atmosphere with the negative of the earth.

This neutralisation should not take place in a manner very uniform or regular. It is evident that the variations in the mists or conducting capabilities of the atmosphere will be attended by variations in the facility of this neutralisation.

These differences will be evinced by the deviations or disturbances of the magnetic needle, which will be sensible at great distances from the poles, as in the temperate zone where they are often observed. The western deviation which in the middle latitudes usually precedes an aurora, indicates a large accumulation of electricity, due to a powerful condensation of vapors in the polar regions, which by facilitating the reunion of the two electricities, augments the intensity of the terrestrial current passing in our hemisphere from the equator to the north, and consequently carries the needle more to the west. When the aurora is once visible, the current becomes less strong, because the light itself of the aurora is proof of the resistance (probably due to the congelation of the particles of water suspended in the air that constitutes the mist) which the reunion of the two electricities encounters;* the needle will then retrograde to the east, as actually takes place.

In the higher latitudes, the disturbances of the needle are continual, because the slightest differences in the intensity of the electric discharges that take place in the polar regions should be there perceived. As to the observations of MM. Ginge, Löwenörn and Lottin, that the maximum deviation of the needle takes place from 8 to 10 o'clock in the evening, and the minimum at 9 to 10 in the morning, they were made only during some weeks in summer, and they prove only that at this season of the year, the greatest amount of condensation of moisture takes place, as should be the case, at times just preceding and following the setting of the sun, and the least 7 or 8 hours after its rising. In the observations of Lieutenant Hood, made in the voyage of Captain Franklin, between the 1st of February and the 31st of May, the greatest declination took place at 8 and 9 o'clock in the morning, and the least at an hour after noon. Thus, as is seen, the times of the maxima and minima are widely variable in those high latitudes, where there are great differences in the length of the day, and also in temperature, and therefore considerable electric disturbances of the air.

It is a singular fact, sometimes noticed, that when an observer is in the midst of an aurora, so to speak, the action on the needle may be null. This was remarked by Mr. Forster, at Port Bowen, beyond 65° N., the latitude of Forts Franklin and Enterprise, where Dr. Richardson had on the contrary observed the action of the needle. In fact, a needle in the interior of the circle formed by

* It is clear that the mist when first formed should be a better conductor than when, afterwards, it consists only of icy particles.

the aurora about the magnetic pole, is no longer under the influence of the currents which circulate around it and not above or below, and it ought therefore to experience only a variable and irregular action.

I have said that the aurora was probably of daily occurrence, and varied only in intensity. These differences in intensity are the reason for its being not always perceptible, and also for its less frequency remote from the magnetic poles. As to the differences of number for each month, they are attributable to two causes—but especially to the unequal length of the nights, for there should be fewer in the shorter nights. Thus in May, June and July the fewest are seen, because the days are the longest, while in the nine others, and especially in March, September and October, they are most numerous. This preëminence of these three months above others of still shorter days, can be due only to this, that the auroras are most frequent at the times of the equinoxes, and especially the autumnal equinox. This is readily understood if we consider that the vernal equinox is the time when the sun transfers to the northern hemisphere its powerful influence either direct or indirect in the development of electricity; and that the autumnal should be followed with a large condensation of the vapors accumulated in the atmosphere during the months of summer—a condensation which, as already explained, facilitates the neutralisation of the two electricities, developed in large quantities during the summer, and augments consequently the intensity of the discharge at the pole.

It has been pretended that in the appearances of the aurora borealis there are secular variations; in other words, that there are epochs comprising a certain number of years during which auroras are particularly frequent, and others in which they are rare. This opinion does not appear to me to be based on documents sufficiently exact to be admitted. There may be a difference in different years, as there is a difference in temperature and humidity. But this is far from making out a periodicity in auroras: to establish such a periodicity, there ought to be the collected observations of a century, from observers at least as good, and as favorably situated with reference to the magnetic poles, as those now engaged: and this we have not. We need not therefore dwell longer on this point, only remarking that if really such a periodicity exists, it might be connected with the change in the magnetic poles, which are the centers of the aurora, and which according to the surface about them would more or less facilitate the electric circulation: for it is evident that the naked soil would afford more ready circulation than a surface covered with a great thickness of ice. But, I repeat it, the fact of the periodicity is far from proved.

Recapitulation.—1. All observations agree in demonstrating that the aurora borealis is a phenomenon taking place in our atmosphere, and that it consists in the production of a luminous ring whose center is the magnetic pole, and having a diameter more or less large.

2. Experiment demonstrates that in causing in highly rarified air the reunion of the two electricities near the pole of an artificial magnet, a small ring of light is produced similar to that which constitutes the aurora, and having a like movement of rotation.

3. The aurora is consequently due to electric discharges taking place in the upper regions between the positive electricity of the atmosphere and the negative electricity of the earth—the electricities being separated by the direct or indirect action of the sun, principally in the equatorial regions.

4. As these electric discharges take place constantly, though with varying intensity, depending on the state of the atmosphere, the aurora should be a daily phenomenon, more or less intense, and consequently visible at greater or less distances, and only when the night is clear—which accords precisely with observation.

5. The phenomena that attend the aurora, such as the presence and form of the cirro-stratus clouds, and especially the disturbances of the magnetic needle, are of a kind to demonstrate the truth of the electric origin attributed by the author to the aurora—an hypothesis with which these phenomena correspond even in their minutest details.

6. The aurora australis, according to the few observations on it which have been made, presents exactly the same phenomena as the aurora borealis, and is explained in the same manner.

Art. XXXVIII.—*Notice of three ponderous masses of Meteoric Iron at Tuczon, Sonora;* by Charles Upham Shepard, M.D.

The first intimation concerning the locality here noticed, was afforded in 1851, at the Meeting of the American Association for the Advancement of Science, on the occasion of my describing before the Chemical and Natural History section of that body, the meteoric stone of Deal, New Jersey. Dr. J. L. Le Conte being present, and having just returned from California through the province of Sonora, stated to the meeting, that "while passing through the village of Tuczon, a frontier town of Sonora, near the Gila, in the month of February previous, he observed two large pieces of meteoric iron, which were used by the blacksmiths of the town for the purposes of anvils. He was unable to procure any specimens from these bodies; but was guided to a cañon

between two mountain ridges in the immediate vicinity from which both pieces had been taken, where the masses of meteorites were so abundant as to have given name to the cañon. He had not before heard any account of this remarkable circumstance, and had considered it an interesting subject for observation."*

Nothing farther was brought to light respecting this very remarkable locality, until the present season, on the return of Lieut. John G. Parke, of the United States Topographical Engineers, from his scientific explorations in Sonora, when he had the goodness to address me a letter of inquiry respecting them, attended with about an ounce weight for my examination, which he had procured in person from one of the masses.

Lieut. Parke observed in his letter that "the Alcaide and Commandante would not consent to our removing the masses, even had we possessed the means; but by dint of two hours hard labor, we managed to chip off a few fragments, which I hope may serve the purposes of analysis."

I immediately set myself to the best examination of the subject, which the limited supply of materials and the facilities at hand, permitted.

The fragments were small; the largest piece not weighing above one-quarter of an ounce, and that somewhat battered by the process employed for its separation. Still, it showed the natural outside of the meteor. It was destitute of a well marked crust, and much coated with oxyd of iron, evincing in common with the other fragments, that this iron is prone to undergo a rapid oxydation on exposure to the weather.

The fresh surfaces presented the color and lustre of white cast-iron; though it is not brittle, or granular in its fracture. A close examination of a fresh surface, produced by the cold chisel, reveals frequent white spots, of the size of a pin's head and smaller, scattered in every direction, and without any very perceptible order. These spots seem to be owing to the presence of an earthy powder, which adheres closely to the iron, and indeed seems partially imbedded therein. When such a surface is highly polished on the burnishing wheel, the spots disappear; but are renewed again on the application of acids, in the etching process. They then come into view, rather more circumscribed in their areas than before; but of a very determinate figure, being mostly rounded or oval, sometimes with angular indentations in their borders. They are never rhomboidal or rectangular in their outline, after the manner of the much larger earthy grains, or crystals, in the Atacama iron, which render the latter porphyritic, when cut into slabs. The Tuczon iron on the contrary, when thus polished and etched, is amygdaloidal only; and to discern this character thoroughly, requires the aid of a microscope.

* Proceedings of the American Association for the Advancement of Science, Sixth Meeting, p. 188.

The acids act very tardily on the iron, and require to be aided by heat, before the action will fairly commence. No decided crystalline structure is developed in the process; though the fragments experimented on, being small, and considerably altered in molecular texture by the force applied in their separation from the parent mass, it would not be safe from this trial perhaps, to conclude against a crystalline structure in the main portion of the iron.

Sp. gr. = 6·66, which corresponds very nearly with that of the Atacama iron, as determined by Turner, whose trial specimen no doubt included the earthy constituent of that iron.

No sulphur was detected in those fragments that were acted upon by acids; but here again, it would not be strange if this very common element of meteorites should hereafter be detected, when a larger portion of the mass comes to be examined.

The most striking phenomenon that presented itself during my examination of the Tuczon iron, was the following. A white, insoluble powder came into view throughout the liquid, as the solution of the iron proceeded in nitro-hydrochloric acid; and at the conclusion of the process a considerable precipitate of this powder was obtained, among which were little ovoidal grains of a milk-white mineral and occasionally also, others of the same figure that were perfectly limpid, like hyalite; while others still were milky on one side and limpid on the other,—thus evincing that the milky and the limpid mineral, was one and the same species. Indeed I was led to regard the mealy powder also, as partaking of the same nature; and such was the general resemblance of the whole, to the mineral I have called chladnite, in the meteoric stone of Bishopsville, South Carolina, that I am led to refer this earthy substance to that species: an opinion which is the more probably correct, as I found the acid solution to contain decided traces of magnesia, an earth which it is most likely proceeded from the partial decomposition of portions of the pulverulent, earthy ingredient of the meteoric iron, and not from the iron-alloy. Should this view of the unknown substance prove correct, it will be the first instance in which it has been found in an iron-mass. We shall then have (astropetrologically considered) a second species of meteoric iron, with an earthy admixture; the first being the previously known *peridotic iron*, and the second, that here pointed out, viz., the *chladnitic iron.*

The nitro-hydrochloric solution of the iron, afforded with ammonia in excess, a deep blue liquid, indicative of nickel in a very decided proportion, to the iron.

It remains only to state a few additional particulars concerning these iron-masses, derived from a later letter of Lieut. Parke, which he kindly permits me to annex to this notice.

"The three masses were found in a cañada of the Santa Rita Mountain, about 25 or 30 miles to the south of Tuczon. Two of them were shown to us by the Commandante; both being

used as anvils. One lies within the Presidio, and is of a very peculiar form, it being annular, and somewhat like a seal-ring of huge proportions. Its exterior diameter is about three and a half feet; its interior about two. It weighs nearly 1200 lbs. The other piece is in front of the Alcalde's house. It weighs about 1000 pounds, and has an elongated prismatic form, serving well the purposes of an anvil. It is partially buried in the soil, but having two feet of its length projecting above the ground. The third piece I did not see; but was told that it was much smaller than either of the others. By permission of the authorities, our blacksmith undertook to cut off some specimens, in which, however, he almost entirely failed—the metal being so tough and hard. It yields to the hammer, and has a clear ring, not unlike that of bell-metal. The surfaces were rounded, and rusted,—closely resembling a mass of refined cast-iron that had been exposed to the action of the weather for a long period. The surfaces that have received the blows of the hammer, where used as an anvil, are quite polished.

"To obtain these specimens would be attended with no little difficulty, owing to the remoteness of the locality, and the broken-down condition of animals when reaching this point."

The route of transportation recommended by Lieut. Parke, is that, via. Fort Yuma, distant 275 miles from the locality, on the California side; and from thence by water, to the head of the Gulf of California. Measures are already on foot for the removal of one or more of the masses, to this part of the country, which it is greatly to be desired will be crowned with success.*

Art. XXXIX.—*Reëxamination of American Minerals:* Part IV—*Boltonite; Iodid of Silver; Copiapite; Owenite; Xenotime; Lanthanite; Manganese Alum; Apophyllite; Schreibersite; Protosulphuret of Iron; Cuban;* by J. Lawrence Smith, M.D., Prof. Chem. Med. Depart. University of Louisville.†

37. *Boltonite, identical with Chrysolite.*

Boltonite was first described as a new species by Professor C. U. Shepard. He made the specific gravity from 2·8 to 2·9. It was subsequently examined by Professor Silliman, Jr., who found

* The above Sonora meteoric irons were described and illustrated with figures in a paper by Dr. J. Lawrence Smith, presented to the American Association at its meeting at Washington in April last—a paper which was to have appeared in our last number, but is still delayed. The masses were seen by officers of the late Boundary Commission, and figures are published in Bartlett's Personal Narrative (8vo, 1854), ii, 298.—Eds.

† The absence of Mr. G. J. Brush from America, who was associated with me in the first three parts of these reëxaminations, makes it necessary for me to continue them alone and the absence of his valuable assistance is a matter to be regretted by all who take any interest in the subject.—J. L. S.

3·008 as its specific gravity, with a hardness of from 5 to 6: his analysis gave for its constituents:*

Silica,	46·062
Alumina,	5·667
Magnesia,	38·149
Protoxyd of iron,	8·632
Lime,	1·516

With this knowledge of the mineral, I undertook its examination, on specimens in the gangue furnished me by Prof. Shepard. Examination of different portions separated mechanically from the gangue, made it very evident that the mineral was more or less mixed with other substances which had escaped observation, for no two analyses agreed; and it was soon discovered that it was impossible (from the specimens in my possession at least) to separate Boltonite in a state of purity without the aid of other means than had been adopted.

Boltonite, as is well known, occurs at Bolton, Mass., disseminated in irregular masses and grains in a white limestone. If a piece of the mineral in its gangue be placed in cold dilute hydrochloric acid, the limestone is readily dissolved, and a mass left, which is seen to consist of asbestus, dolomite, a little mica, small crystals of magnetic iron, and a greenish or yellowish green mineral; if the acid be now heated, the dolomite will be entirely dissolved with a little of the last mentioned mineral.

In order to obtain the Boltonite as pure as possible for analysis, the following method was adopted. Pieces were separated by the hammer as thoroughly as possible from all other substances; these were subsequently placed in dilute hydrochloric acid, and boiled for some time; the acid being washed away and the substance dried, it was crushed in a mortar to fragments from the twentieth to the tenth of an inch in diameter; these were again introduced into dilute acid and heated for a short while; the acid was thoroughly washed away, and the mineral dried. The small fragments (now like coarse gravel) were placed on a piece of glazed paper, the hand laid flat upon it and the mineral rubbed so as to grind the particles against each other for the purpose of ridding their surfaces of a little cohering silica arising from its partial decomposition; with a small gauze sieve the finer particles are separated, and from that remaining in the sieve we are enabled with the aid of a glass without any difficulty to pick out the pure Boltonite. This method requires a little patience, but no extraordinary care, and however unpromising the original specimens may have been, there is no difficulty in obtaining a material, the results of whose analysis is constant. From a larger selection of specimens than that used, there doubtless could be obtained pieces perfectly pure of some size. After being satisfied with this method of obtaining the pure mineral, three different portions were pre-

* This Journal, vol. viii, 2d ser., p. 39[illegible].

pared and examined, the first two being of the greenish variety and the third of the yellow variety, which color is doubtless due to a peroxydation of a minute quantity of the protoxyd of iron entering into the constitution of the mineral. Mr. L. Saemann in a communication made to the American Association some time since, attributed this change to magnetic iron undergoing decomposition; but this, however, does not appear to me to be the case, for the reasons that crystallized magnetic iron is a mineral difficult of decomposition, and the color is not in fissures as would be the case if the peroxyd arose from a substance foreign to the composition of the mineral, but enters into its most intimate structure.

The hardness of Boltonite is found to be, as already stated, between 5 and 6. The specific gravity was taken on three specimens; Nos. 1 and 2, on a gramme each of fine particles; No. 3 on a piece of ·150 gramme, all possible precautions being used to arrive at correct results:

No. 1, 3·270 No. 2, 3·208 No. 3, 3·328

No. 3 is to be regarded as by far the most reliable, as in taking the sp. gr. of fine grains it is almost impossible to detach the last particles of air, and consequently the sp. gr. they indicate is below the true number.

The analyses of three portions gave—

	No. 1.	No. 2.	No. 3.
Silica,	42·56	41·95	42·41
Magnesia,	51·77	51·64	50·06
Protox. iron,	2·35	3·20	3·59
Alumina,	0·10	0·25	
Loss by heat,	2·22	1·58	not estimated.
	99·00	98·62	

Nos. 1 and 2 were the greenish variety, No. 3 the yellowish. The oxygen ratio of the silica and protoxyds are—

	No. 1.	No. 2.	No. 3.
Silica,	22·11	21·77	22·03
Magnesia,	20·35	20·30	19·67
Protoxyd of iron,	·52	·71	·75

This being as one to one within a small fraction, the formula therefore is $(\dot{M}g\,\dot{F}e)^3\,\dddot{S}i$, or of the general form $\dot{R}^3\,\dddot{S}i$, which of course proves it to be *chrysolite*, a fact sustained in every respect by its physical characters.

38. *Iodid of Silver.*

In this reëxamination of American minerals it was not originally designed to include those of South America: but my recent examination of the minerals obtained by Lieut. Gilliss of the U. S. Chili Expedition, has afforded an opportunity of analyzing certain minerals that it was well to investigate, and among these

were one or two fine specimens of iodid of silver. A reëxamination of this mineral is especially interesting, from the fact that its composition is still in doubt, owing to the discrepancy between the original analysis of Vauquelin on the mineral from Zacatecas in Mexico, and that of Domeyko on the mineral from Chanarcillo in Chili.

	Vauquelin.		Domeyko.	
Iodine,	22·6	Ag^2 I	46·89	Ag I
Silver,	77·4		54·25	

The constitution of the native Chlorids and Bromids of Silver would lead to the supposition that Domeyko's analysis was the correct one, and this is strengthened by its resemblance to the artificial iodid of silver.

The specific gravity was found to be 5·366, being a little lower than that given by M. Domeyko. The analysis of an exceedingly pure specimen gave me—

	1.	2.
Iodine,	52·934	53·109
Silver,	46·521	46·380
Chlorine,	*trace*	*trace*
Copper,	*trace*	*trace*
	99·455	99·489

clearly showing its constitution to be

$$\text{Ag I} = \text{Iodine } 53{\cdot}85, \text{ Silver } 46{\cdot}15 = 100,$$

leaving no doubt of its perfect analogy to the natural chlorid and bromid of silver. The other properties of this mineral are not mentioned, as they are all fully stated in all works on mineralogy.

39. *Copiapite.*

This mineral was also furnished me by Lieut. Gilliss, it having been brought from Chili. It consists of most beautiful silky fibres or fibrous masses of a pearly lustre. Its color is white with a very slight tinge of yellow. From the specimens in my possession there was no difficulty in picking out a portion in a state of great purity. Its specific gravity is 1·84. Examined under the microscope its form appears to be a hexagonal prism. Cold water has but little action on it, merely causing the crystals to separate and the mass to swell out to a very much increased bulk. If the water be boiled, decomposition ensues with a deposition of the oxyd of iron and the formation of a soluble sulphate. On analysis it afforded

	1.	2.
Sulphuric acid,	30·25	30·42
Peroxyd of iron,	31·75	30·98
Water,	38·20	not estimated.
Undissolved,	0·54	
	100·74	

The analyses correspond to the formula

$$\ddot{\text{F}}\text{e}\,\dddot{\text{S}}^2 + 11\dot{\text{H}}.$$

This is the same formula as that obtained by Rose, with an additional half atom of water, his formula being

$$2\text{F̶e} \bar{S}^2 + 21\dot{H}.$$

Protoxyd of iron was looked for but none found.

40. *Owenite,* identical with Thuringite—with an announcement of a new locality.*

Owenite was first described by Dr. F. A. Genth as a distinct species, who gave a minute and accurate analysis in the Am. Journ. of Science, vol. xvi, 2d series, p. 167. It was found on both sides of the Potomac river near Harper's Ferry. The physical characters being already fully and accurately given, it is needless to repeat them here, merely remarking that its specific gravity as taken by me is 3·191. It is readily soluble in hydrochloric acid; notwithstanding, analysis No. 2 was made by fusion with carbonate of soda. Results of analyses as follows:

	1.	2.	Genth.
Silica,	23·58	23·52	23·21
Peroxyd of iron,	14·33		13·89
Alumina,	16·85	16·08	15·59
Protoxyd of iron,	33·20	32·18	34·58
Protoxyd of manganese,	0·09		*trace*
Magnesia,	1·52	1·68	1·26
Lime,	——		0·36
Soda,	0·46		0·41
Potash,	*trace.*		0·08
Water,	10·45	10·48	10·59
	100·50		99·97

After this examination it was rendered strongly probable that Owenite and Thuringite were similar if not identical minerals; yet, in the analysis of Thuringite by Rammelsberg, alumina is not mentioned as one of its constituents. This view was sustained by the apparently perfect accordance in the physical characters of the two minerals, coupled with the fact that the amount of silica and water in the two, as already examined, was the same, and also the sum of the oxyds of iron and alumina in the Owenite were equal to the sum of the oxyds of iron in the Thuringite. To settle the question, it became necessary to reëxamine Thuringite, of which I obtained a specimen from Mr. Markoe, coming from the original locality; it was slightly altered by the action of the air, but this could interfere only with the correct estimate of the protoxyd of iron. Its specific gravity was 3·186, and its composition,

* The identity of these two minerals has already been announced by me in a letter to one of the editors of this Journal (Am. Jour., xvii, 131), but no details were then given.

Silica,	22·05
Peroxyd of iron,	17·66
Alumina,	16·40
Protoxyd of iron,	30·78
Magnesia,	0·89
Soda, Potash,	0·14
Water,	11·44
	99·36

The peroxyd of iron is a little higher, and the protoxyd a little lower than in the analysis of Owenite, but this arose from the partial decomposition of the specimen. The correct analysis of Thuringite is that first given, and the formula deduced by Mr. Genth from it is to be looked upon as the correct one, namely—

$$2\dot{R}^3\,\bar{S}i + \bar{\bar{R}}^3\,\bar{S}i + 6\dot{H},$$

corresponding to the oxygen ratio for

$$\dot{R},\ \bar{\bar{R}},\ \bar{S}i,\ \dot{H},\quad 1 : 1·5 : 1·5 : 1.$$

In looking over some minerals placed in my hands by Mr. Markoe, I have found a specimen of Thuringite coming from the Hot Springs of Arkansas. Its identity is made out without the slightest difficulty, as all its physical characters correspond most perfectly with the Thuringite, its sp. gr. being 3·184 and composition—

Silica,	23·70
Peroxyd of iron,	12·13
Alumina,	16·54
Protoxyd of iron,	33·14
Magnesia,	1·85
Manganese,	1·16
Soda, Potash,	0·32
Water,	10·90
	99·74

An interesting fact connected with this mineral as shown by this investigation is, that although not crystalline, or at least very obscurely so, yet coming as it does from three localities so widely separated as Thuringia, the Potomac, and Arkansas, it is nevertheless found quite unmixed with any other mineral, as the analyses indicate.

41. *Xenotime of Georgia.*

In examining a few years ago some of the residue of gold washings from Clarksville, Georgia, in the possession of Prof. Gibbes of Charleston, I observed some small octahedral crystals associated with zircon, titaniferous iron and kyanite. Two or three of the most perfect were selected, and having no goniometer at hand, they were sent to Mr. Teschemacher, who referred them, after a partial examination, to Zircon. Prof. Gibbes subsequently examined their form, and pronounced them Xenotime, (Am. Jour. Science, 2nd Ser., xiii, 143). Since then, from ma-

terial that had been placed in my hands by that gentleman, nearly a gramme of the substance has been procured, and upon that the following examination has been made.

Some of the crystals are exceedingly short prisms surmounted by four-sided pyramids, but most of them are without the prism, the summits coming together forming a flattened octahedron. The measurements made were: over the pyramidal edge 123° 10′, over basal 81° 30′, face of pyramid on prism 131° 40′. The above measurements can be made with perfect accuracy; not so the faces of the prisms on each other, and as far as I could make it out, I am inclined to think that they are not square prisms, but rhombic prisms of 93°. Its hardness is 4·5, sp. gr. 4·54, and the physical characters those given for Xenotime.

It was decomposed by fusion with carbonate of soda and silica, and analysed with the following results:

Phosphoric acid,	32·45
Yttria,	54·13
Oxyd of Cerium, (with a little $\dot{L}a$ and $\dot{D}$)	11·03
Oxyd of iron,	2·06
Silica,	0·89
	100·56

This analysis will be seen to differ from that of the Xenotime of Hitteroe, Sweden, by Berzelius, in that a portion of the yttria is replaced by the oxyd of cerium; the formula represented by the analysis is, however, the same, namely,

$$(\dot{Y}, \dot{C}a)^3 \dddot{P}$$

Great care was taken in the separation of the oxyd of cerium, which after being peroxydized by heat, yielded but little to dilute nitric acid, indicative of the presence of but a small quantity of the oxyds of lanthanum and didymium.

42. *Lanthanite.*

This mineral was first observed in America by Mr. W. P. Blake, and described in this Journal, Sept. 1853; it was obtained by Mr. Blake from Bethlehem, Lehigh Co., Pa., where only one specimen had been found. It was handed to me for examination, and ascertained to be carbonate of lanthanum; the analysis made was given in the original description of the mineral. Since then I have made another analysis on a portion remaining in my possession, and although not differing from the former one, it is thought proper to insert it in this paper.

	1.	2.
Water,	24·21	24·09
Carbonic acid,	21·95	22·58
Protoxyd of Lanthanum (with some oxyd of Didymium),	55·03	54·90
	101·19	101·57

No. 2 is the analysis already published in the paper before mentioned. In both instances, there was an excess, owing to the peroxydation of a portion of the lanthanum,—a circumstance that cannot be avoided, nor do we know how to allow for it in our calculation. This mineral has the same formula as the artificial carbonate, namely, $\dot{La}\,\ddot{C}+3\dot{H}$ = Carbonic acid 21·11, oxyd of lanthanum 52·94, water 25·95.

The only other known locality of this mineral is Bastnäs in Sweden; it is there found only as a coating to Cerite, and doubtless was not obtained in a perfectly pure state by Hisinger, who gave as its formula, $\dot{La}^3\ddot{C}+3\dot{H}$. I have no doubt as to the minerals being identical, and that whenever the Bastnäs variety is obtained crystallized, it will prove to have the same composition as the Bethlehem variety.

43. *Mangano-magnesian Alum from Utah.*

This alum was observed a few years ago by Dr. Gale, among specimens brought from the Salt Lake, in Utah, by Mr. Stansbury. It occurs at a place called Alum Point, and was considered altogether a manganese alum, of which Dr. Gale gave what he then stated he considered an imperfect analysis (Am. Journal Science, vol. xv, 2nd ser., 434):

$\dddot{S}$ 18·0 $\dot{Mn}$ 8·9 $\dddot{Al}$ 4·0 $\dot{H}$ 73·0

Being desirous of having it more carefully analyzed, Dr. Gale placed in my hands the specimen which is the subject of the present investigation. It was not received as it occurs at the locality, but had been recrystallized and consisted of delicate needle-shaped crystals, adhering in small masses. It dissolves very readily in water; in fact so soluble is it that it is difficult to decide the amount of water requisite for its complete solution. It crystallizes from solution in the form of delicate crystals, with a plumose aggregation. On analysis it furnished:

Alumina,	10·40	10·65
Magnesia,	5·94	5·65
Manganese,	2·12	2·41
Sulphuric acid,	35·85	35·92
Oxyd of iron,	0·15	0·09
Potash,	0·20	0·20
Water,	46·00	46·75
	100·66	101·67

This analysis shows an amount of protoxyds a little too high for the requisites of the formula of alum, but this however, is of frequent occurrence in the natural alums, owing to admixture of impurities. This variety of alum has been before observed by Stromeyer, and was brought from a cave in Southern Africa. Its formula is,

$$(\dot{Mg}, \dot{Mn})\dddot{S} + \dddot{Al}\,\dddot{S}^3 + 24\dot{H}$$

44. *Apophyllite.*

The specimen of this mineral examined, came from Lake Superior. It is eminently lamellar in its structure, and was placed in my hands as being possibly diaspore; its lustre is however much more pearly than this latter mineral. Its sp. grav. is 2·37, and its constitution,

Silica,	52·08
Lime,	25·30
Potash,	4·93
Fluor,	0·96
Water,	15·92
	99·19

45. *Schreibersite (of Patera).*

This meteoric mineral occurs in the American meteorites in more abundance than has usually been supposed, as was fully shown in a communication made to the Am. Assoc. for the Advancement of Science in April, 1854; and as that memoir will be published in full in this Journal, nothing farther than the mere statement of the analysis of this mineral is here given. G. = 7·017.

	1.	2.	3.
Iron,	57·22	56·04	56·53
Nickel,	25·82	26·43	28·02
Cobalt,	0·32	0·41	0·28
Copper,	*trace*, not estimated.		
Phosphorus,	13·92		14·86
Silica,	1·62	not estimated.	
Alumina,	1·63	not estimated.	
Lime,	*trace* not estima'd	not estimated.	
Chlorine,	0·13	not estimated.	
	100·66		99·69

Nos. 1 and 2 were separated mechanically from the meteoric iron; No. 3 chemically. The silica, alumina and lime, were almost entirely absent from No. 3; and in the other specimen it is due to a siliceous mineral that I have found attached in small particles to the Schreibersite, and of which I have preserved one or two small specimens.

The formula of Schreibersite I consider to be $Ni^2 Fe^4 P$.

		Pr. ct.
Phosphorus,	1 atom,	15·47
Nickel,	2 "	29·17
Iron,	4 "	55·36

Further particulars of this mineral will be found in the paper already referred to.

46. *Protosulphuret of Iron.*

This sulphuret is the one found in the meteoric irons of this country. The specimen examined came from Tennessee; its sp. gr. is 4·75. Its composition is different from that of magnetic

pyrites, although some authors consider the magnetic pyrites a protosulphuret, an inference not sustained by analysis. The mineral in question afforded me

Iron,	62·38
Sulphur,	35·67
Nickel,	0·32
Copper,	*trace*
Silica,	0·56
Lime,	0·08
	98·91

The formula Fe S requires Sulphur 36·36, Iron 63·64 = 100.

Further remarks on this mineral will be found in the paper on meteorites.

47. *Cuban.*

This variety of copper pyrites was first noticed by Breithaupt, as occurring among the copper ores of Cuba. Desiring to reëxamine it, specimens were obtained from Prof. Booth; they were massive and not perfectly pure, furnishing an insoluble residue consisting of silica and oxyd of iron which are very probably combined. Its sp. grav. was 4·180, and its composition—

	1.	2.	3.
Iron,	37·10		
Copper,	18·23	19·10	19·00
Sulphur,	39·57	39·20	39·30
Residue (silica and oxyd of iron),	4·23		
	99·13		

This seems to substantiate the formula already received, (agreeing with the analyses of Prof. Booth,) $Cu\,S + Fe^2\,S^3$, pyrites being $Cu^2\,S + Fe^2\,S^3$ = Sulphur 42·28, Copper 20·82, Iron 36·90.

Art. XL.—*Correspondence of M. Jerome Nicklès, dated Paris, June* 28, 1854.

Academy of Sciences.—For some days, the Academy has been occupied repairing the loss experienced at the beginning of the year. In place of Dr. Roux, Dr. Claude Bernard has been named, well known for his discoveries in Physiology: in place of Admiral Roussin, an officer of the navy, M. Bravais, an admiral in science, although but a lieutenant in his official capacity. The labors of M. Bravais have not been confined to navigation and hydrography. He has published important mathematical works; his researches on halos, auroras, mirage, the rainbow, parhelia, and meteorology in general, have given him a prominent name in Physics, while his works on the arrangement of leaves on branches, the symmetry of inflorescence, the laws of growth of the Pinus sylvestris, have made him known to naturalists.

On the Phenomenon called "Spirit-rappings."—The time not occupied by the discussion of the titles of candidates, has been filled with communications, some of them of interest. The question also of "table-turnings," and "spirit-rappers," has engaged the attention of a physiologist of Francfort, Dr. Schiff, who has given in a full session, a demonstration showing that the noise of the "spirit-rappers" is not the result of a stroke of any part of the body on an external object; but that it is produced by means of the great peroneus muscle, the tendon of which passes behind the external malleolus, to which it is usually retained by a ligament. When this ligament fails, or when it is much relaxed, if the muscle is suddenly shortened, the tension of the tendon becomes so great that it slips suddenly from the malleolus, producing a noise similar to that of a stretched cord suddenly loosened.* M. Schiff by practice has become able to make these sounds at will; and he has given proof of it before the Academy: seated in a semi-circle, and in profound silence, they heard him produce the described sound for more than a minute. Restored from their surprise, the Academy hastened to change the subject, as if ashamed to occupy itself with the scientific explanation of a fact which for some time has occupied the popular imagination.

Electricity—*Electro-chemical action.*—Works on Electricity have specially occupied the attention of physicists in France. M. Becquerel, Sr., the inventor of the constant battery, and who was the first to form minerals by means of electricity, notwithstanding his advanced age, works with the activity of his youth. One of the ideas which constantly urges him onward in new efforts at progress, is the conviction that we have yet disengaged only a feeble part of the electricity which is associated with the molecules of matter, because of the recomposition which takes place through the contact of bodies. It is precisely a cause of this kind which interferes with the constancy of the batteries employed for chemical purposes. Plates of platinum used as electrodes become covered with gas, and take polarity; and consequently they give origin to contrary currents which necessarily diminish the effect of the pile. To avoid such disturbing causes, M. Becquerel has contrived two pieces of apparatus for constantly depolarizing the electrodes, making them at every moment to change their polarity. The author has exhibited his apparatus in action before the Academy, and has since applied it to the study of the principle which governs the disengagement of electricity in chemical action, a principle which he first brought out in 1823, and which since has been adopted in the science.

* Dr. Austin Flint of Buffalo, at the commencement of the "spirit-rapper" delusion, exposed the source of this noise in the same way precisely as Dr. Schiff.—Eds.

His depolarising apparatus gives him a more constant current than had been obtained, and serves as a means of verifying the results he before arrived at, which are for the most part confirmed. The following are his conclusions:

1. In the action of acids on metals, or on saline solutions, the acids or acid solutions take always an excess of positive electricity; the metals and alkaline solutions, a corresponding excess of negative electricity.

2. The disengagement of electricity in combustion is governed by the same principle; the combustible body disengages negative electricity, the supporter of combustion, positive.

3. Decompositions produce inverse electric effects.

4. There is no disengagement of electricity as long as the two bodies in hand are conductors of electricity: thus in the combination of a metal with oxygen, iodine, or dry bromine, electricity is not produced.

5. In the mixture of acids with water, or in their combination with it, water acts as a base; whilst it acts as an acid, as regards alkaline solutions.

6. Concentrated solutions of a neutral salt act with reference to water, as regards electrical effects produced, in the same manner as acids with reference to bases.

7. Acids in their combination or their mixture with other acids act in such a way that the acids the most oxydising are the most electro-positive; in their combinations with bases, the acids appear to retain the same property, so that in the reaction, in the case of the mixture of two solutions saturated with a neutral salt, the nitrate is positive with reference to a sulphate, the sulphate with reference to a phosphate, &c.

8. When several acid solutions, neutral or alkaline, are placed alongside of one another, so as to mix slowly, the electric effects produced are the resultant of the individual effects which take place at each surface of contact.

9. Contrary to the opinion of Volta, we may make an electric chain, or rather a closed circuit solely with liquids, in which an electric current will circulate, and by which phenomena of decomposition and recomposition may be obtained, if there are in the circuit bodies which are conductors of electricity. Living organised bodies present numerous examples of a circuit of this kind, giving place to electro-chemical effects, which have not yet been studied.

While occupied with the study of the principle governing the disengagement of electricity in chemical action, M. Becquerel has endeavored to bring the principle to a practical use. A long time since he applied it to the treatment of ores, and he has succeeded in extracting lead and silver from their respective ores without the intervention of heat, beyond what is necessary in a simple

roasting. An experiment has been made on more than 30,000 kilograms of ores from Mexico and different parts of the globe. The great solvent which he uses is common salt. We will give further details in our next communication.

Pyro-electric currents.—In the course of the preceding experiments, M. Becquerel observed that glass in fusion was a conductor of electricity. This conductibility begins to be sensible at 300° C. He has not been slow in finding a means of applying the heat lost in furnaces to the production of electricity. In view of this conductibility of glass in fusion, he substitutes it for acids and aqueous saline solutions in a battery. He obtains thus an element of a battery which remains constant, and which is sufficiently energetic to decompose water. Compared with a Bunsen's couple of the same size, it has about one-fourth the intensity.

These batteries, which in distinction from the hydro-electric and thermo-electric, M. Becquerel calls pyro-electric batteries, may be arranged in different ways. The following are two:

1. In a crucible placed in a furnace, pulverised glass is introduced, with 0·25 of carbonate of soda to hasten fusion; then a long bar of iron and another of copper are inserted in it, being fixed in a vertical position, and separated from one another. It is perceived that in this battery the soluble metal is the iron which is in fact oxydized; but this oxyd becomes dissolved in the mass in fusion, and the metal is constantly kept bright.

2. The barrel of a pistol is taken, and in it a tube of green glass is inserted enclosing a cylinder of copper; after having filled all the interstices of the barrel and of the tube with powdered glass, the whole is placed horizontally in a furnace, and the barrel and the copper cylinder are put in communication with apparatus for collecting the electricity.

These currents are not thermo-electric; for if the glass is removed, a galvanometer put in communication with the iron and copper rests at zero.

M. Becquerel considers it probable, in view of these pyro-electric currents, that terrestrial electric currents exist in contact with or near the junction of the solid part of the globe with the part in fusion, where there may be solid conducting substances partially empasted in the melted silicates in the manner of a pyro-electric couple.

On the electricity produced during the evaporation of salt-water.—For a long time it was admitted, on the researches of M. Pouillet, that the electricity produced during the evaporation of water containing a saline substance in solution, was due to the chemical segregation of the two substances, water and salt. Some years since, M. Riess and M. Reich showed that this electricity proceeded from the friction of the water against the sides

of the vase. This fact is proved anew by the researches just published of M. Gaugain, although the results obtained differ in the details from those of the German physicists.

Economical illumination by Electric light.—The last winter, the General Dock Company, hurried in the founding of its establishment, was obliged to work night and day. It undertook to remove in a short time the whole of a considerable hill: 1600 workmen, 800 at a time, were kept at work without interruption. In order to illuminate the works during the hours of the night, they proposed to use electric light. This mode of illumination has been often used in Paris in works at night; but in this case it was continued for 4 months, and proved to be an economical method of lighting. Fifty of Bunsen's elements were at once in action, and when the light after a while diminished, another 50 were substituted. Two electric lanterns served to light the space where the 800 workmen were employed. The expense per lantern was as follows:

Superintendent, per day,	4·50 francs.
Mercury,	5·00
Zinc,	4·50
Points of charcoal,	1·40
Nitric acid,	1·80
Sulphuric acid,	1·84
Total,	19·04

The cost, hence, of lighting the 800 workmen, was 38 francs 8 centimes per night, or 4½ centimes per man. This is a very considerable economy, and the work went on with a regularity which would have been impossible with any other mode of illumination; and besides it was accomplished without any danger, although the place was incessantly traversed by locomotives engaged in transporting the earth.

Decomposition of Kyanite by galvanic heat.—Another use has been made of electricity, and this of a chemical nature. On attaching to one of the charcoal points of a Bunsen's battery of 80 elements a small lamellar fragment of kyanite, which, as is well known, is very infusible, M. Duvivier has succeeded in fusing it in 3 or 4 minutes; the elements of which it consists were in part dispersed, and the aluminium, freed from oxygen, appeared at the surface of the substance in fusion. A small globule became fixed to the surface of the assay, which was flattened on cooling; and other globules remained imbedded in the melted mass. The author has extracted some of the supposed aluminium, but has not examined its physical properties, and we cannot say that it was pure; it may have contained silicium, proceeding from the silica. Has this deoxydation been produced by the heat

alone? Some physicists may think so. For ourselves, we believe that the reduction is due to the volatilised carbon; for it is well known that the luminous arc is never produced without a transfer of material, and the material transferred in this case is nothing else but incandescent carbon.

Electro-magnetic Machine.—On the Report of M. Becquerel, the Academy of Sciences has decreed to M. Marié-Davy, Professor in the Faculty of Sciences of Montpelier, a reward of 2000 francs for an electro-magnetic machine of his invention. In this machine, the electro-magnets act *by contact.* There is a cylindrical armature in communication with the axis which by its action it puts in motion, and which revolves in a circle carrying at intervals horse-shoe magnets. An analogous machine has been described and since patented in England by Mr. Talbot. We are ignorant of the force of Talbot's machine; that of Marié is very feeble, and we doubt if electricity will ever replace steam so long as the battery is not more economical. To increase the force of his motor wheel, the Academy has engaged M. Marié to replace the cylindrical armature by circular electro-magnets acting by opposite poles on the horse-shoe magnets. By this means, he will increase much the force without adding to the expense. M. Marié is now occupied with this improvement.

Magnetism by Rotation.—A German Journal relates the following experiment without mentioning the author. A watch-spring, not magnetic, suspended at centre by means of a fibre of silk, remains in equilibrium in any position, regardless of the earth's magnetism. But if a pistol containing a lead ball is fired directly beneath the spring, parallel to it, the spring becomes magnetic and takes the position of a magnetic needle. The author of the journal attributes this magnetism to the shock or undulation of the air produced by the passage of the ball.

We may give a simpler explanation, if we suppose the ball, which has a rotary movement in its passage, to become magnetic under this influence, as we have claimed in our remarks on the origin of the earth's magnetism.* Once magnetised, it induces magnetism in the steel spring, acting thus like an ordinary magnet. By interposing a screen between the spring and the line of the ball, it will still be magnetised if our explanation is correct, and also if the ball is fired above in a contrary direction the polarity should be the same, provided the ball has the same rotation in each case. Although this is only conjecture for the future to verify, I will take this opportunity to correct an opinion too formally expressed in the note on page 117 of this Journal, vol. xvii, written when discouraged after being disappointed in several trials; I hope soon to establish the contrary and without having recourse to the experiment alluded to above.

* This Journal, January, 1854, xvii, 116.

Experiments with reference to firing mines by electricity.—This subject which has received much attention, is to become of practical value through the efforts of Colonel Verdiè and Captain Savare of the Engineer Corps, who propose to substitute in place of Bunsen's battery for firing the powder, the machine of Ruhmkorff,† or that of Clarke. An interesting report on the subject made to the Academy by Marshal Vaillant, Minister of War and member of the Institute, announces the result as accomplished. But as the process for the purposes of war must be rendered familiar by practice to be of value, M. Vaillant does not consider that the time for using the process has yet come. He has ordered renewed trials, and to contribute toward it on his side, he has given the necessary orders that each School of Engineers shall have a Ruhmkorff's apparatus at its disposal. The processes employed by M. Verdiè and M. Savare differ somewhat, each in points of importance, but there is no space to describe them here.

Various Memoirs.—For want of space, we can only allude to the following papers:—An *Electric thermometer*, fitted for a boiler or an apartment kept at a constant temperature, by M. Maistre.—*Researches on the influence of Chloroform on the Sensitive Plant*, by M. Leclerc, showing that it is impressed by it perhaps like animals.—*Treatise on the relation which exists between the electro-motive force of the muscular current and that of different sources of dynamical electricity*, by Jules Regnauld.

In the science of Optics there have been several papers, among which we mention, *The determination of the emissive powers of bodies for light*, by MM. de la Provostaye and Desains; these experimenters have operated with incandescent bodies; platinum is more emissive than gold; and the emissive power of gold is 10 times more feeble than that of oxyd of copper.

Chemistry has as usual been richly represented. In the first place, M. Biot announces to the Academy the publication of the posthumous work of Laurent, entitled "Méthode de Chimie," and read on the occasion, the note with which he accompanies the work, and in which, under the form of *advice to the reader*, he points out the special end which Laurent proposed in his great work. A translation of this note is published in the latter part of this volume.—M. Rivot, superintendent of the Laboratory at the School of Mines, has brought forward *new methods of treating ores of copper.*—M. Frémy has communicated the results of his *researches on the ores of Platinum.*—The same chemist has presented two extended memoirs *on the composition of the eggs of different animals*, an investigation carried on in connection with M. Valenciennes, the zoologist.—M. Dessaignes is studying the *products of the transformation of creatine.*—M. C. Montrand has experimented *on the more economical manufacture of*

† This Journal, Jan., 1853.

phosphorus by treating phosphate of lime with carbon and chlorhydric acid.—Finally, the investigators of aluminium are giving themselves much labor, but still do not succeed in preparing this metal except at great expense.

Dilatation and Contraction of Metallic Plates.—The instruments for measuring dilatations of metallic plates are of great delicacy, giving results with very close precision. There are cases, however, in which a hundredth of a millimeter in difference of length may be of value, and this is the fact with the standard meter, the basis of the metric decimal system. M. Silbermann, Superintendent of the Conservatory of Arts and Trades, has just carried the precision to 3-thousandths of a millimeter. It is known that a rule suspended by one end becomes elongated thereby, and one standing on its end, owing to its weight, is shortened: and by placing the rule in a horizontal position again, it is supposed to take its original length. By employing his process, the germ of which is presented in a former work of this physicist,* M. Silbermann has shown that the rule that has been suspended retains its increased length when placed horizontally; and so with the rule that has stood on its end. The difference is only in thousandths of millimeters; still if it can be measured, this is sufficient reason why it should not be neglected.

New Greek Fire.—The war in the east has stimulated the zeal of those in Europe who are interested in improving the art of destruction. Projects the most remarkable and curious are proposed. Being persuaded that one of the means of preserving peace to humanity consists in perfecting our methods of destroying life, and not desiring that in this respect one nation should be more favored than others, we mention here some of the projects which rest on serious principles.

The Greek fire has at different times engaged attention without its being exactly known in what it consists. In 1755 a goldsmith of Paris, named Dupré, discovered an inflammable liquid which burned under water. Louis XV. allowed him to make experiments in the canal of Versailles, and then in different seaports, to try the power of the liquid in setting vessels on fire. It is said that the results produced were terrific. However the king believed it his duty to refuse the advantages which the invention promised. He withheld Dupré from publishing his discovery, and gave him a pension. Dupré died and carried off his secret.

In the month of April last, the photographer, Niepce de St. Victor, while studying benzine as an ingredient of a varnish, observed that this carburet,—which is very inflammable in the open air and at a low temperature by the simple contact of a small flame, while being insoluble in water and having a density

* This Journal, January and March, 1853.

of 0·85,—has eminently the property of burning on water. He then remarked that on throwing on water some benzine containing a fragment of potassium or of phosphuret of calcium, either of these substances set fire promptly to the benzine, by becoming inflamed through contact with the water.

In two experiments made each time with 300 grammes of benzine and half a gramme of potassium contained in glass vessels, the breaking of these vessels as they floated on the water, caused the benzine to spread over a large surface; the potassium taking fire produced an immense flame, which was very hot, and continued for about one minute, notwithstanding a strong wind in one case and a smart shower of rain in the second.

The first experiment was made on the 30th of April, on the Seine, and the second on May 2nd, in the basin of the Jardin du Palais Royal.

By request of the Minister of War, M. Niepce undertook to examine into the liquids susceptible of burning when used in the interior of hollow projectiles. In concert with M. Fontaine, a manufacturer of chemical products, he set himself to the work, and obtained the results here given. A mixture consisting of 3 parts of benzine and 1 of sulphuret of carbon, being put into a hand-grenade, previously heated to a temperature below that of boiling water, produced a disengagement of vapor which took fire on contact with a small flame; and a fine jet of flame was obtained much less smoky than that of pure benzine, and which continued to burn until the whole was consumed. For heating the hollow projectile, either a moment's immersion in boiling water, or contact with burning coals may be employed.

The mixture of benzine and sulphuret of carbon, of the proportions mentioned, floats on water, and its flame has remarkable burning qualities, when the sulphuret contains some phosphorus in solution; and it is proposed to use it in setting fire to wood. Oil of naphtha and oil of petroleum highly rectified are nearly as inflammable as benzine, and burn on water as readily. But their flames are not so hot. The oil of petroleum, benzine and sulphuret of carbon, as they are not expensive, it is proposed to use in war, either for burning an enemy's vessel, or for defending a place. We have read in the Journal "Cosmos," a programme prepared by a General of Engineers for defending a besieged town, and doing the greatest amount of mischief to the assailants.

Coupled Cannons.—This is another weapon of war, the effects of which may be terrible. It is brought forward by M. Ador. Two cannon have the same breech, and diverge at a given angle; they have a common charge of powder, a single touch-hole and a single cap. In each of these cannon, which are accurately bored and polished, a piston of a cylindrical form is fitted, having the same calibre as the cannon, carefully turned, polished

and greased. These two pistons are united together by an iron cord or wire when used with a musket, or by an iron chain from a meter to a hundred meters in length when with cannon. The pistons serve as projectiles; when fired, they straiten the chain between them, and flying through the air, they sweep every thing before them.

Photography—Heliographic engraving.—The following process invented by M. Baldus, appears to bring to perfection the method of engraving by the aid of the sun. The results obtained are very beautiful; and although the author has not described to us fully all the details, we know enough to give a general idea of his method.

On a plate of copper covered with petroleum a photographic proof on paper of the object to be engraved is placed; this proof is a positive, and will necessarily make a negative on the metal by the action of the light. After an exposure of a quarter of an hour to the sun, the image is reproduced on the resinous coating, but it is not yet visible; it is made to appear by washing the plate with a solvent which removes the parts not impressed by the light, and brings out a negative picture made by the resinous tracings of the bitumen. The designs are very delicate; the tracings receive solidity by an exposure during two days to the action of a diffuse light. When thus hardened, the plate of metal is plunged into a bath of sulphate of copper and is then connected with the pole of a battery; if with the negative pole, a layer of copper in relief is deposited on the parts of the metal not protected by the resinous coating; if with the positive pole, the metal is graved out in the same parts, and thus an etched engraving is obtained.

So that at will a raised or etched engraving may be made, the former to be printed like a wood-cut, the latter like ordinary copper plate engraving.

Collodion.—At one of the recent sessions of the Academy of Sciences, MM. Bisson brothers exhibited a photograph of the principal front of the Louvre; it was a positive on paper, 140 centimeters in length and 60 high, produced from a negative on collodionised glass. It consisted of 3 separate photographs, as similar in tone of coloring as if taken at a single operation. The operation was made with "collodion anticipé," the plates having been prepared in the workshop, and carried to the place after having been rendered sensitive; the authors affirm that these plates preserve their sensitiveness for several hours.

Société d'Encouragement pour l'Industrie Nationale.—We briefly allude to the recent annual session of this Society, held as usual for the distribution of medals to inventors who have become distinguished during the year by their inventions, and also to foremen who have been noted for their morality, intelligence,

and spirit of invention. Twenty-five among these latter have received bronze medals as well as books. All were distinguished for having made some improvements in the processes of their manufactures. Medals of bronze, of gold, or of platinum have been awarded to inventors, whose inventions have been successfully carried out. Some among these are already known to our readers; they are,—M. Dubrunfaut, for his economical production of alcohol from the juice of the beet;* MM. Girard and Aubert, for the impulse they have given to the caoutchouc industry;† M. Mirand,‡ for the successful application of the Electrical Telegraph to the wants or convenience of private life. We propose to describe another time his apparatus, which is already in use in several large houses.

We should also mention a dynamometer of excellent construction, for measuring the resistance to rupture of a band of tissues, an instrument which the public authorities, the manufacturers of tissues, and the marine propose to adopt, as it is admirably adapted for trying the strength of tissues, cordage, &c. The author of this dynamometer, M. Perreaux, received a platinum medal.

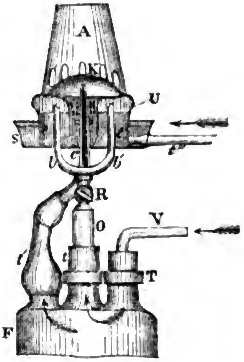
The session of the Academy was closed by a very fine address by the President, M. Dumas, on the past and future of Electricity. The poetic imagination of the orator more than once carried him too far. From reading the discourse one would seriously believe in the diamonds prepared by M. Despretz by means of the galvanic battery. The electro-magnetic machine of Mariè-Davy was represented as completed, and as realizing the force of a one-horse steam engine, at an expense of 2 francs per day: the public has believed it, and there will be a grievous disappointment for M. Mariè-Davy on the day when the machine he has proposed to construct, is put in action.

Economical Lamp for obtaining high temperatures.—M. H. St. Claire Deville, Professor of the Normal School, in order to carry on analysis by the dry way and the reduction of ores at this school, has been led to contrive an economical lamp capable of affording all the heat required. He burns a hydro-carburet purchased at little cost in the shops. Camphene would answer equally well.

In the lamp, the burning fluid used is brought to the state of vapor and inflamed before a blowpipe with a large aperture, the air of which is furnished by the bellows of an enameller's lamp. But a few seconds are required to raise a platinum crucible to the temperature of melting iron.

In the annexed figure, F is a reservoir furnished above with 3 tubulures, T, *t*, *t'*. By means of the bellows the air is injected into F through the tube V, which is inserted in T; *t* carries the

* This Journal, Sept. No., p. 274. † Ibid, p. 277. ‡ Ibid, Jan., 1853.



vertical tube O, which has a stopcock at R, and above divides into the two arms b, b', which pass into a metallic box U, and terminate in its upper part in open extremities cut off obliquely. The box U contains the burning fluid e, partly filling it; it connects with a reservoir by t'', which is kept at a constant level. The centre of this box is a cylindrical tube, closed below, through which passes the blowpipe e, a continuation of the tube t', the left tubulure (in the figure) of the flask F. The tube which is at the middle of the box U, and envelops the blowpipe c, has several small holes u, u, communicating with the empty (or upper) part of the box U.

Above the blowpipe, and resting in a furrow in the top of the box U, there is a copper cup K, pierced at the centre with a hole for the passage of the jet of vapor which escapes from the holes u, u, u, after the bellows are put in action.

To prevent the burning fluid from becoming too much heated, there is a trough S, containing water. Before lighting the lamp, the fluid in L is heated till the water in the trough boils; then the bellows are made to act, and the jet of vapor is lighted; after which the heat disengaged by the lamp is sufficient to continue the vaporisation of the fluid.

Above the box L, there is a chimney A, having a series of holes around, near its bottom, for drawing in air on the flame of the apparatus.

M. Deville observes that those hydro-carburets which give the densest vapors, and also have the lowest boiling point, afford the most heat.

ART. XLI.—*Observations on the Nomenclature of the metals contained in Columbite and Tantalite;* by Prof. A. CONNELL.*

IN 1801 Mr. Hatchett announced the discovery of a new metallic substance, contained as an oxygen acid combined with oxyd of iron in an undescribed heavy black mineral from Connecticut. To this new metal Mr. Hatchett gave the name of *columbium*, and the ore in which he found it has usually in this country been called *columbite*. A year afterwards Ekeberg announced a new metal which he called *tantalum*, in two Swedish minerals, which he distinguished by the names of tantalite and yttrotantalite.

* Phil. Mag., June, 1854, p. 461.

A few years afterwards, Dr. Wollaston conceived that he had succeeded in establishing that columbium and tantalum are identical; and this view was tacitly acquiesced in by the greater portion of the chemical public for many years, the metal and its ores usually obtaining in this country the names of columbium and columbite, and on the Continent the names of tantalum, and tantalite and yttrotantalite. A mineral was also discovered at Bodenmais, which was held to contain this same metal.

This state of things continued till about 1846, when M. H. Rose of Berlin published a series of researches on the ores from these different localities, from which, so far as I can understand the matter, he drew the following conclusions: first, that the metal in the Swedish tantalite is a distinct metal, with its peculiar oxygen acid and other combinations, and for this metal, the name of tantalum may be with great propriety reserved, being the metal discovered by Ekeberg, and by him called *tantalum;* secondly, that in the Bodenmais and American minerals two metals are contained, which M. Rose proposed to distinguish by the names of Niobium and Pelopium, the latter being supposed to be nearly allied to tantalum, but the former quite distinct in its characters.*

This view of Rose has more or less prevailed for the last eight years; although I confess it had always occurred to me, and occasionally I have spoken out the view, that Mr. Hatchett's memory had been rather hardly dealt with, since M. Rose had left him entirely out of view, although truly the first discoverer of the first known of these metals and minerals.

When cerium was ascertained not to be a pure metal, but to contain lanthanum and didymium mixed with it, no one thought of dropping entirely the name of cerium. It still belongs to an acknowledged metal, and the rights of its discoverers are unimpaired.

Precisely the same observation applies in regard to yttria and the new oxyds of erbium and terbium.

Other examples of the same kind might be quoted.

Now, on the authority of such precedents, when it was thought to be ascertained that the American columbite and the analogous Bodenmais mineral did not contain *one* new metal only, but at least two, justice seems to have required that the name of columbium should have been reserved for the more abundant of these two, just as the names of cerium and of yttrium have been preserved.

But how much more strongly does such a view hold good *now*, when it has been announced by M. Rose that the American and Bodenmais mineral contain only *one metal*, and for this metal he actually proposes the name of niobium?† Does it not follow very

* See Chemical Gazette, vol. iv, p. 349. † Ibid, vol. xii, p. 149.

clearly that this metal ought to have the name of *columbium?* M. Rose has now come to the same conclusion at which Mr. Hatchett arrived fifty years ago, when he announced that one new metal, to which he gave the name of columbium, existed in the American mineral columbite. If the countrymen of the latter most distinguished analytical chemist have any sense of justice or regard for the memory of an eminent man—one with whom I am proud to say I had a slight acquantanee, and from whom I received some kindness—they will now unite for the future in support of his just right not to be forgotten and entirely laid aside in this matter. There cannot be a better opportunity than the present for taking this step.

I am very far from wishing to overlook the important researches of M. Rose on this, as on so very many other interesting topics, and we shall always feel grateful for his further investigations regarding columbium and its various oxyds and other combinations. But we ought not to overlook what was done before him.

The matter is now reduced to a very simple issue.

We have *columbium* in the American and Bodenmais columbites, and probably now in some other minerals.

We have *tantalum* in Swedish tantalite and yttrotantalite, and probably in some other minerals.

Of all courses, one of the most ill-advised seems that followed by some English chemists, of giving occasionally the name of columbium to tantalum, which, as I understand the matter, is now quite ascertained to be different from any of the other metals. This course can only lead to confusion. Tantalum is not columbium.

Art. XLII.—*Murchison's Siluria.**

[This recent work by Sir R. I. Murchison is an able and instructive summary of the history of the earliest rocks that contain organic remains.

In 1839 Sir R. I. Murchison published his Silurian System in two parts, in a quarto of 768 pages copiously illustrated. This was followed in 1845 by another great work of 652 pages quarto, embellished with the most ample and beautiful views, sections, maps, &c., illustrating the geology of Russia in Europe and the Urals. As a companion, a second volume of 512 pages appeared at the same time, devoted to the Paleontology of the

* Siluria: The History of the oldest known Rocks containing Organic Remains with a brief sketch of the distribution of Gold over the earth. By Sir Roderick Impey Murchison, F.R.S., F.L.S., etc. etc. 523 pp. large 8vo, with 37 plates and many wood-cuts. *London*, 1854.

regions explored, illustrated by 50 quarto plates. These volumes on Russia and the Urals are the joint production of Sir R. I. Murchison, Mr. Edouard de Verneuil of France and Count Alexander von Keyserling of Russia.

The recent work of Sir R. I. Murchison is an able resumé of all that has been done by these writers, together with the results of other laborers in the science, among whom are Professor Sedgwick of Cambridge, England, the geologists of the Ordnance Survey in Great Britain, and many eminent men on the continent of Europe and in America. The observations on gold and its distribution, with which the volume closes, are of much practical value, although only incidentally connected with the main object of the work.

The important labors of the author of Siluria have been carried through with signal ability, and at a great outlay of time and money. Geology is largely indebted also to Prof. Sedgwick for his researches among the oldest fossiliferous rocks. But Murchison appears to have first made out the correct relations of these early strata. To him we owe the judicious exposition of the whole subject in the elaborate works which he has put forth. The candor and liberality manifested by the author are worthy of the works which they adorn. His investigations have extended above the coal, into the New Red Sandstone, the Permian beds, and the Triassic, and the present work embraces these limits. The full exhibition of these great zones of primeval life, from its earliest dawn through many successive ages, to the era of the first reptiles, is most interesting and instructive. A general review of the subject, partly historical and partly expository, is presented in the introductory chapter of the Siluria which we here cite. We take pleasure in thus showing our appreciation of the extended labors of the author.—B. S.]

The earliest condition of the earth is necessarily the darkest period of its geological history. The favorite hypothesis concerning the origin of the planet, founded on astronomical and physical analogies, is, that it assumed the form of a flattened spheroid from rotation on its axis when in a fluid state. Reasoning upon this idea, and looking to the structure of those rocks which either lie at great depths or have been extruded from beneath, the geologist has inferred that the crystalline masses, including granites which issued out from below all other rocks, and constitute possibly their existing substratum, were at one time in a molten state. The theory of a central heat, at first sufficiently intense to maintain the whole terrestrial mass in a state of fusion, but subsequently so far dissipated by radiation into space, as to allow the superficial portion to become solid, has been adopted by the greater number of philosophers who have grappled

with the difficult problem of the first conditions of our planet. Most of them likewise have believed that all the great outbursts of igneous matter, by which the crust has been penetrated and its surface diversified, were merely outward signs of the continued internal activity of that primordial heat, now much repressed by the accumulations of ages, and of which our present volcanoes are feeble indications. If, then, the mathematician has correctly explained the causes of the shape of the globe, the geologist confirms his views when, examining into the nature of its oldest massive crystalline rocks, he sees in them clear proofs of the effects of intense heat. This original crust of the earth was subsequently, we may believe, broken up by protruded masses, which issuing in a melted condition, constituted the axes and centres of mountain chains. Each great igneous eruption gave out substances that became, on cooling, solid rocks, which, when raised into the atmosphere, constituted lands that were exposed to innumerable wasting agencies; and thus afforded materials to be spread out as deposits upon the shores and bed of the ocean. In these hypothetical views concerning the production of the earliest sediments formed under water, we seem to reach a primary source; and once admitting that large superficial areas were originally occupied by igneous rocks, we have in them a basis from which the first sedimentary materials were obtained.

The earlier eruptions having necessarily occasioned elevations at some points and collapses or depressions at others, such changes of outline, aided by the grinding action of water, would occasion the formation of bands of sediment, which, adapting themselves to the inequalities of the surface, must have been of unequal dimensions in different parts of their range. In this way, we may imagine how, by a repetition of the processes of elevation and denudation, the earliest exterior rugosities of the earth would be in some places increased, while in others they would be placed beyond the influence of sedimentary accumulation. May we not also infer, that the numerous molten rocks of great dimensions which were suddenly evolved from the interior at subsequent periods, must have made enormous additions to the solid crust of the earth, and have constituted grand sources for the augmentation of new strata?

Turning from the igneous rocks to crystalline stratified deposits, we now know that a great portion of the micaceous schists, chloritic and quartzose rocks, clay-slates, and limestones, once called primary, were of later origin. Many of these are nothing more than subaqueous sediments of various epochs, which have been altered and crystallized at periods long subsequent to their accumulation. This inference has been deduced from positive observation. Rocks, for example, have been tracked from the districts where they are crystalline, to spots where the mechan-

ical and subaqueous origin of the beds is obvious, and from the latter to localities where the same strata are wholly unchanged, and contain organic remains. Transitions are thus seen from compact quartz rock, in which the grains of silica are scarcely discoverable with a powerful lens, to strata in which the sandy, gritty, and pebbly particles bespeak clearly that the whole range was originally accumulated under water. Other passages occur from crystalline, chloritic, and micaceous schists, to those clay-slates which are little more than consolidated mud, and from crystalline marble to common earthy limestone, in which organic remains abound. These and similar metamorphoses embrace the consideration of changes, like those, for example, by which ordinary limestone has been converted into dolomite and sulphate of lime or gypsum, or shale into mica-schist, as is seen in the secondary and tertiary rocks of the Alps.*

Elementary works will have, indeed, informed the student, that such changes of the original sediment have been generally accounted for by the influence of great heat proceeding from the interior of the earth, and which at different former periods manifested its power in the eruption of granites, syenites, porphyries, greenstones, and other substances formed by fusion. Let it, however, be understood, that the prodigious extent to which the metamorphism of the original strata has been carried in mountain-chains, and at different periods through all formations, though often probably connected with such igneous outbursts, must have resulted from a far mightier agency than that which was productive of the mere eruptions of molten matter or igneous rocks. The latter are, in fact, but partial excrescences in the vast spread of the stratified crystalline rocks,—symptoms only of the grand changes which resulted from deep-seated causes; probably from the combination of heat, steam, and electricity, acting together with an intensity very powerful in former periods.

Processes now going on in nature on a small scale, or imitated artificially by man, may enable us to comprehend imperfectly in what manner some of these infinitely grander ancient metamorphoses were effected; and the experimental science of chemistry when more extensively applied to the analysis of rocks, will, it is hoped, some day reveal still more important truths in this, which is still one of the most obscure points in the range of geological phenomena.

But speculations on such physical operations as those which have affected the surface of the earth, are not here called for. At all events, the earliest of the phenomena, with which alone we are at present concerned, or the first formation of the known crust of the planet, belongs to a period in which no definite order,

* See Alps, Appenines, &c., Quarterly Journal Geol. Soc. Lond., vol. v, p. 157, *et seq.*

—still less any trace of life,—has been deciphered by human labor.*

The design of this work is much more attainable. Its aim is to mark the most ancient strata in which the proofs of sedimentary or aqueous action are still visble,—to note the geological position of those beds which in various countries offer the first ascertained signs of life, and to develop the succession of deposits, where not obscured by metamorphism, that belong to such protozoic zones. In thus adhering only to subjects capable of being investigated, it will be seen, that geology, modern as she is among the sciences, has revealed to us, that during cycles long anterior to the creation of the human race, and while the surface of the globe was passing from one condition to another, whole races of animals—each group adapted to the physical conditions in which they lived—were successively created and exterminated. It is to the first stages only of this grand and long series of former accumulations, and to the creatures entombed in them, that attention is now directed.

The convictions at which I have arrived being the result of many years of research, I have been urged by numerous friends to give a condensed, and, as far as is practicable, a popular view of the oldest sedimentary rocks and of their chief organic remains, and thus to throw into one moderate-sized volume the essence of my large works,† as sustained by the publications of many other authors.

Geologists are now pretty generally agreed, that the oldest organic remains which are traceable, pertain to the lower division of the rocks termed Silurian; but before any description of these ancient deposits, or of those preceding them, is given, a few words are required, in explanation of the researches by which our acquaintance with the earliest vestiges of life and order in the protozoic world has been attained.

One of the chief steps which led to the present classification, as admitted by my contemporaries, was the establishment of the "Silurian System" of rocks and their imbedded fossils. Before the labors which terminated in the publication of the work so named, no one had unravelled the detailed sequence and characteristic fossils of any strata of a higher antiquity than the Old Red Sandstone; and even that formation was only known to be the natural base of the Carboniferous or Mountain limestone, and to contain a few undescribed fossil fishes. Not only were the re-

* The reader who desires to study the laws by which the superficial temperature of the earth has been regulated in the immensely long subsequent geological periods, will find them well explained in the profound essay of Mr. W. Hopkins, "On the causes of changes of *climate* at different geological periods," Quart. Journ. Geol. Soc. Lond., vol. viii, p. 56.

† See Silurian System, Murchison, 1839; and Russia in Europe and the Ural Mountains, by Murchison, de Verneuil, and de Keyserling (J. Murray, 1845).

lations and contents of all the inferior strata undefined, but even many rocks which are now known to be younger than the Silurian, were then considered to be of much more remote antiquity. No one had then surmised, that the great series of hard slates with limestones and fossils, which have since been termed Devonian, is an equivalent of the Old Red Sandstone, and younger than, as well as distinct from, the deposits of the still older Silurian era. On the contrary, British authorities believed (and I was myself so taught) that the schistose and subcrystalline rocks of Devonshire and Cornwall were about the most ancient of the vast undigested heaps of greywacke. In short, the best geologists* of my early days were accustomed to leave off with such rocks, as constituting obscure heaps of sediment, in and below which no succession of "strata as identified by their fossils" could be detected. The result of research, however, has been the elimination of several well-defined groups, all of which were formerly merged in the unmeaning German term "grauwacke." (See Chapter 14.)

Desirous of throwing light on this dark subject, I consulted my valued friend and instructor, Dr. Buckland, as to the region most likely to afford evidences of order, and by his advice I first explored, in 1831, the banks of the Wye between Hay and Builth. Discovering a considerable tract in Hereford, Radnor and Shropshire, wherein large masses of grey-colored strata rise out from beneath the Old Red Sandstone, and contain fossils differing from any which were known in the superior deposits, I began to classify these rocks. After four years of consecutive labor, I assigned to them (1835) the name Silurian, deriving it from the portion of England and Wales, in which the successive formations are clearly displayed, and wherein an ancient British people, the Silures, under their king Caradoc (Caractacus), had opposed a long and valorous resistance to the Romans. Having first, in the year 1833, separated these deposits† into four formations, and shown that each is characterized by peculiar organic remains, I next divided them (1834, 1835) into a lower and upper group, both of which I hoped would be found applicable to wide regions of the earth. After eight years of labor in the field and closet, the proofs of the truth of those views were more fully published in the work entitled the "Silurian System" (1839).

* See those classical works, the first Geological Map of Mr. Greenough, and the Geology of England and Wales, by the Rev. W. D. Conybeare.

† For the first tabular view of these four formations, the bottom one resting on the unfossiliferous greywacke of the Longmynd, see Proceedings Geol. Soc. Lond., vol. ii, p. 11, Jan. 1834. The characteristic fossil species were even then enumerated, and hence the classification which is now sustained is essentially twenty years old. It had even been previously stated by me, that the lowest known fossil-bearing formation, or the "*black trilobite schists and flags of Llandeilo, probably exceeded in thickness any of the suprior groups.*"—Proc. Geol. Soc., vol. i, p. 476, 1833.

During my early researches, it was shown that the lowest of these (1833) fossil-bearing strata reposed, in the west of Shropshire, on a very thick accumulation of still older sediment, as exposed in the ridge of the Stiper Stones, and the Longmynd mountain; and the strata of the latter not offering a vestige of former life, they were consequently termed unfossiliferous greywacke.

At that time it was also supposed, that the contiguous slaty region of North Wales, then under the examination of Professor Sedgwick, consisted of rocks, in part fossiliferous, and of an enormous thickness, which rose up, according to my friend and fellow-laborer, from beneath my Silurian types. Hence, another term, or that of Cambrian, was afterwards, or in the year 1836, applied to masses supposed to be inferior, before their true relations to the Silurian strata of Shropshire and Montgomeryshire had been ascertained. This assumed inferiority of position in the slaty rocks of North Wales being considered a fixed point, it was naturally thought, that such lower formations, the fossils of which were then undescribed, would be found to contain a set of organic remains, differing as a whole from those of my classified and published Silurian system. With other geologists, therefore, I waited for the production of the fossils which might typify such supposed older sediments; for in obtaining all the knowledge I had then acquired, by receding from upper strata whose contents were known to lower and previously unknown rocks, I had invariably found that the latter were characterized by many distinct and new organisms. This fact, which had been first established in the tertiary and secondary deposits, was thus proved to be universally applicable by the occurrence of similar distinctions in the Carboniferous, Old Red, and Silurian rocks.

It was, however, in vain that we looked to the production of a peculiar type of life from the "Cambrian" rocks. Silurian fossils were alone found in them; and the reason has since become manifest. The labors of many competent observers in the last fifteen years have proved that these rocks are not inferior in position, as they were supposed to be, to the lowest stratified rocks of my Silurian region of Shropshire and the adjacent parts of Montgomeryshire, *but are merely extensions of the same strata;* and hence the looked-for geological and zoological distinctions could never have been realized. In the following chapters it will be shown. how Sir H. De la Beche, Professors Ramsay and E. Forbes, with Mr. Salter, and other geologists and palæontologists have demonstrated, that the fossil-bearing rocks of North Wales are both in their order and contents the absolute equivalents of the chief mass of the strata which had been described and named by me "Lower Silurian" in Shropshire and Montgomeryshire. These Government geologists have used my nomenclature in all

their works relating to North Wales, and have, in short, determined the question physically, as well as zoologically.*

But although in 1839, when my first work was completed, I held, in common with Professor Sedgwick, the erroneous idea of the infra-Silurian position of the rocks of North Wales, I soon saw reason to abandon that view, and to adopt (in the year 1841) the opinion which I have subsequently maintained. Thirteen years have elapsed since I was persuaded that the view I then took must be adhered to; first, because it had been ascertained that in Scandinavia, Russia, Bohemia, and other countries, the oldest traces of former life were the same as the lower Silurian types of the British Isles;—and next, because many of the fossils figured in my work as Lower Silurian had been detected in the slates of Snowdon, which were then considered to lie near the bottom of the so-called "Cambrian rocks."

The leading object, therefore, of the present work is, I repeat, to bring out the "Silurian System," not as a mere abridgment of its original form; but such as it finally became in the year 1849, when it was honored with the highest distinction which the Royal Society bestows,† and what it has proved to be, with the geographical and other additions made to it by the government surveyors at home, and by numerous geologists in other countries.

In extending my own researches to various distant lands, I found that as the true base of all rocks containing fossil remains was clear in Scandinavia, Russia, and Bohemia, and as the same fact was announced from North America, it was no longer difficult to describe the whole organic series *from a beginning*, and thus to record the succession of animals from their earliest known developments. In a word, as chroniclers of lost races, my associates and myself were enabled to register in our "Russia and the Ural Mountains," the types of former creatures from their apparent dawn. To the first chapters of that work, the reader is referred as fully explanatory of views which are here reiterated.‡

* See also Phillips, on the Malvern and Abberley Hills.—Memoirs, Geol. Surv., vol. ii, part 1, 1848.

† The Copley Medal.

‡ The reader who desires to consult the documents which explain how my induction was arrived at, is referred to a memoir entitled, "On the meaning attached to the term Silurian during the last ten years," which will indicate to him all my successive publications on this subject, including a geological map of England and Wales, published by the Society for the Diffusion of Useful Knowledge, in 1843. (Journal of Geol. Soc. Lond., vol. viii, p. 173. See also the memoir entitled, "On the meaning attached to the term 'Cambrian System,' and on the evidence since obtained of its being geologically synonymous with the previously established term 'Lower Silurian,'" Journ. Geol. Soc., Lond., vol. iii, p. 165.) At the same time that I must protest against the recent proposal to absorb my Lower Silurian into his Cambrian Rocks, let me record my high estimation of the original memoirs of Professor Sedgwick, especially those on North Wales, Cumberland, and the adjacent counties, which stand upon their own intrinsic merits. The publication on the palæozoic fossils of the Cambridge Museum, which he is bringing out in conjunction with

Then it was, that positive proofs, derived from a wide field of observation, enabled us to commence geological history, with an account of the entombment of the earliest animals recognizable in the crust of the globe; and also to indicate the successive conditions which prevailed upon the surface, in a long series of ages, and during the many changes of outline which preceded the present state of the planet. Then it was, that looking to the whole history of former life, as exhibited in the strata, it was demonstrated from phenomena in one great empire alone (as had to a great extent been shown in Britain), that during the formation of the sediments which compose the crust of the earth, the animal kingdom had been at least three times entirely renovated; the secondary and tertiary periods having each been as clearly characterized by a distinct fauna as the primeval series. In the work on Russia the sequence was thus followed out truly, from the most ancient fossil-bearing strata to the most recent stages in the geological series.

In this volume attention is chiefly restricted to what has proved to be the protozoic, or first era of life. The plan, therefore, pursued will be, so far, similar to that which was adopted in the earlier chapters of the work on Russia; and these first leaves of geological history will be written from the clear traces of a beginning,—a plan which, for want of knowledge, was impracticable in Britain when the "Silurian System" was published.

After a short sketch of the earliest and unfossiliferous sediments, full descriptions will be given of the Silurian rocks (Lower and Upper), followed by very brief accounts of the three overlying groups of palæozoic life, the Devonian, Carboniferous, and Permian.

The Devonian rocks were in previous years known only as the Old Red Sandstone, a name which has, indeed, become classical through the writings of Hugh Miller. These were termed Devonian, because the strata of that age in Devonshire, though very unlike the Old Red Sandstone of Scotland, Hereford, and the South Welsh counties, contain a much more copious and rich fossil fauna, and were demonstrated to occupy the same intermediate position between the previously described Silurian and Carboniferous rocks. At that time, however, none of the fossil fishes of the Scottish or English Old Red had been found in the sandstones, slates, schists, or limestones of Devonshire, or the

Professor M'Coy, will be, I doubt not, a lasting monument in the history of geological science. If that work had been published eighteen years ago, or in 1836, my friend, seeing that his Bala and my Llandeilo rocks were identical, might have proposed (although my fossils were first named and classified) that the Lower Silurian should be merged in the Cambrian. But, now that the terms Lower and Upper Silurian have been adopted in every country, the question is settled. My deep regret on the occasion of this difference of opinion has been expressed in the Preface; for in general views, as in private friendship, we are cordially united.

Rhine, and objections might have been raised to the opinion formed of the age of the deposits. But the discovery made in Russia,* and afterwards extended to Belgium and the Rhenish provinces, of Scottish ichthyolites being associated with numerous mollusca of the Devonshire rocks, firmly established the truth of the comparison.

The Carboniferous rocks, so elaborately and usefully developed in the British Isles, have been already well investigated by many writers, particularly by Professor Phillips, and have been found to extend, like the Silurian and Devonian, over immense regions in all quarters of the globe.

The great primeval or palæozoic series is now known to terminate upwards, in Europe, with certain deposits, for which, in the year 1841, I suggested the name of Permian. In the early days of geological science in England, this group was classed with the New Red Sandstone, of which it was supposed to form the base. But extended researches have shown from the character of its imbedded remains, that it is linked to the carboniferous deposit on which it rests, and is entirely distinct from the Trias, or New Red Sandstone, which, overlying it, forms the base of all the secondary rocks. The chief calcareous member of this Permian group was termed in England the Magnesian Limestone, in Germany the "Zechstein;" but as magnesian limestones are of all ages, and as the German "Zechstein" is but a part of a group, the other members of which are known as "Kupferschiefer" (copper slate), "Rothe todte liegende" (the Lower New Red of English geologists), &c., it was manifest that a single name for the whole was much needed. After showing how these variously named strata constituted one natural group, I therefore proposed to my fellow-laborers, de Verneuil and A. de Keyserling, that the vast Russian territory of Perm should furnish the required name. The term Permian† has, indeed, been adopted by several German authorities, and also by the Government Geological Surveyors of Britain.

In the opening chapter on the geology of Russia, we gave a general view of this palæozoic classification, as applied to Germany, France, Belgium, and North America; in all of which countries, as well as in Russia, it was shown, that a similar ascending order prevailed, from a base line of recognizable Silurian life, up through Devonian and Carboniferous deposits. In the nine years which have elapsed since the issue of that work, considerable additions have been made to our knowledge, and all of them sustain the truth of our generalization. We then scarcely knew of the existence of true Silurian deposits in Germany; nearly all the greywacke of the Rhenish provinces and the Hartz

* See Russia in Europe and the Ural Mountains, vol. i, p. 64.

† "Penéen" of D'Omalius d'Halloy. (See Chapter 12.)

having been assigned to the Devonian series. But since the opening out of the rich Silurian basin of Bohemia, which, in the hands of M. Barrande, has become the palæozoic centre of the continent, Thuringia and Saxony have been also found to contain Silurian rocks.

In Spain, several mountain chains have been shown by M. de Verneuil to consist of Silurian, followed by Devonian and Carboniferous rocks; whilst, in Portugal, Mr. Sharpe has described the first and last of these groups. Even Sardinia has exhibited, under the scrutiny of General A. della Marmora, her Silurian and superjacent coal deposits. Again, as Devonian and Carboniferous strata overlie older rocks in North Africa, and Devonian fossils occur towards Central Africa* and at the Cape of Good Hope, there are already fair grounds for believing, that a similar order pervades the axial lines or ancient mountains of that vast continent.

In northwestern Asia, the chief features of which are described by Humboldt and Rose, my colleagues and myself have explained how the Silurian rocks of the Ural chain are succeeded by younger palæozoic deposits, and Pierre de Tchihatcheff has indicated a great extension of similar formations over large tracts of Southern Siberia and the Altai mountains; whilst in northeastern Siberia, Adolf Erman has traced such rocks even to the Sea of Ochotsk.

In the giant Himalaya mountains, and in Hindostan, where till recently no systematic labors had been devoted to the older strata, we now know, that Silurian rocks, covered by secondary or mesozoic deposits, exist in those the highest mountains of the world; and that the Upper Punjaub contains a limestone charged with well-known carboniferous fossils, reposing, as in England, upon a red sandstone.† There is, indeed, every reason to believe that the mountain-chains of Tartary and China are composed, to a great extent, of these older rocks; for whilst extensive coal-fields have been long worked in the environs of the capital, Pekin, Devonian fossils of the very same species as those of England and the continent have recently been sent from Kwangsi, far to the south of Shangai. Other fossils, identified by de Koninck as Devonian forms, were brought by M. Itier, from the Yuennan province, one hundred leagues north of Canton.‡

* For North Africa, see Coquand, Bull. de la Soc. Géol. de France, 2nde Série, vol. iv, p. 1188. Some of the fossils collected by the enterprising traveller Overweg are also Devonian. For South Africa, the reader must consult a Memoir by Mr. Bain, not yet published in the Quart. Journ. Geol. Soc. Lond.

† The Himalayan data are described by Capt. R. Strachey; those of the Upper Punjaub, by Dr. A. Fleming. (Quart. Journ. Geol. Soc., vol. vii, p. 292, and vol. ix, p. 189.)

‡ See a description of the Chinese coal-field near Pekin, by Kovanko, Ann. des Mines de Russie, An. 1838, p. 191. No geologist can peruse Mr. Fortune's lively de-

In Australia, where a very short time since reference could be made only to rocks of the Carboniferous and Devonian age,* we hear of true Silurian strata containing fossils like those of the British Isles. Some species seem undistinguishable.†

In South America, the lofty Cordilleras and plateaux, whose mineral characters had been so admirably described by Humboldt, are shown by Alcide d'Orbigny to consist in great part of such ancient sediments. Still more clearly has North America been found to contain a vast succession of these palæozoic rocks, and especially of their lower members. Numerous geologists of the United States have demonstrated, that their ancient strata followed the same order on a very grand and usually unbroken scale (particularly in the western region); doubtless due to their having been exempted in such tracts from the intrusion of igneous rocks. Spread out in enormous sheets over the southern districts of Upper Canada, the Lower Silurian strata, invariably so called by every American geologist,‡ are there based on unfossiliferous slates, limestones and sandstones reposing on crystalline rocks, which, extending far northwards, are surmounted by other sedimentary masses similar to strata of the United States, and where Silurian fossils have been detected in limestones amid the polar ices. Adjacent to the southern end of this continent, similar remains have been collected by Darwin in the Falkland Islands.

In few of those regions, however, with the exception of North America (certainly not in the British Isles, where the strata are in many parts much obscured by igneous outbursts), is the sequence so undisturbed as in Scandinavia and European Russia. There, the successive primeval deposits extend over a large portion of the earth in regular sequence and in an unaltered state. Hence, though to the unskilled eye, Russia presents only a monotonous and undulating surface, chiefly occupied by accumulations of mud, sand, and erratic blocks, its framework, wherever it can be detected, exhibits a clear ascending series. The older sedimentary strata, deviating only slightly from horizontality, are there overlaid by widely-diffused masses of those Permian rocks which constitute the true termination of the long palæozoic period.

scription of the Bohea mountains, without suspecting, that a fine primeval succession may there be found. For the Chinese fossils, see Davidson, Quart. Journ. Geol. Soc. Lond., vol. ix, p. 353; and de Koninck, Bull. Acad. Roy. Soc. Belg., vol. xiii, pt. 2, p. 415.

* See Strzelecki's Australia, Foss. Fauna, Morris; M'Coy, Ann. Nat. Hist., 1847. [Also Dana's Rep. Geol. Expl. Exp., where many new species are described.—Eds.]

† Memoir by the Rev. W. B. Clarke, Quart. Journ. Geol. Soc. Lond., vol. viii; see also his collections, and those at the Government Museum.

‡ See particularly the works of James Hall and D. Dale Owen, the Reports of Logan—the chief geologist of Canada.

The following pages, as before said, will be chiefly devoted to the Silurian or first stages of this primeval series. They will be illustrated by wood-cuts representing the most important organic remains, and certain typical pictorial scenes, as well as vertical sections, chiefly taken from my original work. Faithful transfers from the original plates of the "Silurian System," will also be given, in a rearranged form, and with the modern nomenclature of the fossils.

If all the succeeding primeval rocks were to obtain the same amount of illustration as the Silurian, this work would be expanded far beyond the limits to which I must restrict it. The younger palæozoic, or the Devonian, Carboniferous, and Permian deposits, will therefore receive only such a description as may be sufficient to give the student a general view, and stimulate him to acquire a fuller acquaintance with them by consulting the various works wherein they are circumstantially described. But even the sketch of them in this volume will, it is hoped, suffice to show, that while the contiguous strata of two natural groups are intimately linked together by containing some species which are common to both, the principal fossils of each are certainly peculiar.

Although few mineral changes of the strata can be alluded to, an endeavor will be made to show, that gold, however it may now be spread over the surface, was originally accumulated in abundance in the older rocks only (especially in those which have been much altered), and in the associated eruptive masses.

Lastly, it is to be observed, that as the true sequence of the oldest fossiliferous strata was first detected in the British Isles, so the geological descriptions in this volume will be principally derived from our insular examples. At the same time, a general comparison will be instituted with the contemporaneous rocks of different quarters of the globe.

The importance of having, through patient surveys, mastered the obscurities which clouded the history of the earlier periods of animal life will thus, it is hoped, be rendered obvious, in showing that we have now obtained as correct an insight into the first fossil-bearing formations as we had previously acquired of the younger deposits.

Art. XLIII.—*On the Chemical Composition of Clintonite;* by Geo. J. Brush.

The name Clintonite was given some twenty-five years since by Fitch, Mather and Horton to a micaceous reddish-brown mineral occurring at Amity in New York; previous to this, the mineral had been called Bronzite.

In 1832 Clemson* investigated its chemical composition and finding it to differ from Bronzite, gave to it the new name of Seybertite; later, in 1836, it was analysed by Richardson† in Thomson's Laboratory, and apparently unaware of its previous history Thomson considered it a new species and named it Holmsite.

The chemical composition according to Clemson and Richardson is:

	$\bar{Si}$	$\bar{\bar{Al}}$	Fe	$\dot{Mg}$	$\dot{Ca}$	$\dot{Mn}$	$\bar{\bar{Zr}}$	$\dot{H}$	HF	
1,	17·0	37·6	5·0	24·3	10·7	——	——	3·6	——	*Clemson.*
2,	19·35	44·75	$\bar{\bar{Fe}}$ 4·80	9·05	11·45	1·35	2·05	4·55	0·90	*Richardson.*

The unaccountable discrepancy between these analyses led the writer to an examination of its composition.

The specimens analysed were of a reddish-brown or copper-red color and had a sp. gr. of 3·148. H.=5·5. Alone, B.B. infusible, loses its brown color and becomes opaque; heated in a tube gives off a small amount of water, which has a neutral reaction. It is entirely decomposed by concentrated hydrochloric acid, without gelatinizing. A qualitative examination showed the presence of silica, alumina, iron, zirconia, magnesia, lime, potash and soda; no reaction for manganese by Crum's test.

A special examination was made to determine the state of oxydation of the iron; for this purpose the mineral was decomposed by hydrochloric acid in an atmosphere of carbonic acid, the result proved the iron to be peroxyd. Considerable care also was taken in ascertaining whether zirconia was present, as over two pr. ct. were found by Richardson; the iron obtained in the analyses was therefore reëxamined and in every instance an undoubted reaction for zirconia was obtained. On careful examination of the specimens with a magnifier, a dark brown mineral resembling zircon was found to be intimately associated with the Clintonite. A qualitative examination gave all the reactions of zircon,—the writer is therefore inclined to believe that the zircon obtained in the analyses may be due to the associated zircon and not essential to the mineral.

* This Journal [1], xxiv, 171.

† Rec. Gen. Sci. May, 1836, p. 332, and Jour. f. Prakt. Chem., xiv, 38.

In the quantitative analyses, the decomposition was effected by fusion with carbonate of soda; the alkalies were determined by Smith's method with carbonate of lime; the separation of zirconia and iron was made by the presence of tartaric acid in an ammoniacal solution, and the iron was precipitated by sulphid of ammonium. A particular examination was made to prove the purity of all the precipitates obtained. The following are the results of two analyses:

	1.	Oxygen.		2.	Oxygen.	
Silica,	20·24	10·74*		20·13	10·69	
Alumina,	39·13	18·29		38·68	18·07	
Peroxyd of Iron,	3·27	0·98	19·47	3·48	1·04	19·29
Zirconia,	0·75	0·20		0·68	0·18	
Lime,	13·69	3·89		13·35	3·80	
Magnesia,	20·84	8·34	12·55	21·65	8·66	12·78
Soda,	1·14	0·29		1·14	0·29	
Potash,	0·29	0·03		0·29	0·03	
Water,	1·04	0·92		1·05	0·93	
	100·39			100·45		

Only one determination was made of the alkalies. A third incomplete analysis gave, Silica 19·73, oxyd of iron and zirconia 4·15, lime 13·43, magnesia 20·81, water 1·09.

A great difference between the above analyses and those of Clemson and Richardson is in the amount of water. To determine this point the powdered mineral was dried over sulphuric acid and then very powerfully heated by a blast-lamp; in four experiments but a trifle over 1 per ct. was lost.

The analyses do not give a satisfactory formula, the oxygen ratios are:

	$\dddot{Si}$	$\bar{R}$	$\dot{R}$
No. 1,	10·74	19·47	12·55
No. 2,	10·69	19·29	12·78

The relation between $\bar{R}$ and $\dot{R}$ is 3 : 2 or 6 : 4, and the most simple ratio is 3 : 6 : 4, but the silica is in excess and the real ratio is nearer $3\frac{1}{3}$: 6 : 4. If in Clemson's analysis the 5 pr. ct. of iron be considered to be peroxyd ($5·0\ \dot{Fe} = 4·5\ \bar{Fe}$), we have the ratios

$\dddot{Si}$	$\bar{R}$	$\dot{R}$
9·02	18·92	13·76

which seems to render it probable that the true ratio for the mineral is 3 : 6 : 4, from which may be deduced the formula

$$\dot{R}\,\dddot{Si} + \dot{R}^3\,\bar{Al}^2.$$

The European species Xanthophyllite and Disterrite are very nearly related to Clintonite; in all physical characters except color they are identical with it. Their chemical composition as given by Meitzendorf and v. Kobell is:

* Atomic weight of silicium = 21·3.

	$\dddot{\text{Si}}$	$\bar{\dddot{\text{Al}}}$	$\dot{\text{Mg}}$	$\dot{\text{Ca}}$	$\dot{\text{Fe}}$	$\dot{\text{Na}}$	$\dot{\text{H}}$	
Xanthophyllite,*	16·30	43·95	19·31	13·26	2·53	0·61	4·33	*Meitzendorf.*
Oxygen,	8·65	20·53	7·72	3·77	0·56	0·15	3·85	
					$\bar{\dddot{\text{Fe}}}$			
Disterrite,†	20·00	43·22	25·01	4·00	3·60	0·57	3·60	*v. Kobell.*
Oxygen,	10·61	20·20	10·00	1·14	1·08	0·10	3·20	

These differ from Clintonite in containing about 4 pr. ct. of water; if this be considered as replacing magnesia in the manner suggested by Scheerer the relation of the oxygen in the sesquioxyds and protoxyds is nearly 6 : 4; but the ratio 3 : 6 : 4 is not in accordance with the amount of silica obtained in the analyses. If the same replacement be allowed in Disterrite and the iron be assumed to exist as protoxyd, the oxygen ratio will be—

$$\begin{array}{ccccc} \dddot{\text{Si}} & & \bar{\dddot{\text{R}}} & & \dot{\text{R}} \\ 16{\cdot}61 & : & 20{\cdot}20 & : & 13{\cdot}20 \end{array}$$

or almost exactly 3 : 6 : 4.

From these remarks it seems likely that the three species may all be brought under the general formula $\dot{\text{R}}\,\dddot{\text{Si}} + \dot{\text{R}}^{8}\,\bar{\dddot{\text{Al}}}^{2}$ = Silica 19·19, alumina 43·54, lime 11·86, magnesia 25·41.

Munich, August 7th, 1854.

NOTE BY J. D. DANA.—It is important to note that the ratio between the oxygen of the protoxyds and peroxyds together and that of the silica (the water being disregarded), is the same for Clintonite and Disterrite. We thus obtain—

	$\dot{\text{R}}+\bar{\dddot{\text{R}}}$		$\dddot{\text{Si}}$		
1. Clintonite, . . .	32·02	:	10·74	=	3 : 1·06
2. " . . .	32·07	:	10·69	=	3 : 1
3. Disterrite, . . .	32·50	:	10·61	=	3 : 0·98

corresponding each to the ratio 3 : 1. This therefore appears to be the fundamental ratio of the species. We here take the iron in Disterrite as peroxyd, as published by von Kobell, which is its condition in Clintonite; this gives for the oxygen of the protoxyds and peroxyds the ratio 11·24 : 21·26. The formula $(\dot{\text{R}}^{3}, \bar{\dddot{\text{R}}})\,\dddot{\text{Si}}^{\frac{1}{3}}$ expresses the ratio 3 : 1. In the Clintonite, $\dot{\text{R}}^{3}$ is to $\bar{\dddot{\text{R}}}$ as 2 : 3; in the Disterrite nearly as 1 : 2. Expressing the ratio 2 : 3 for the Clintonite, this formula becomes $(\frac{2}{5}\dot{\text{R}}^{3}+\frac{3}{5}\bar{\dddot{\text{R}}})\,\dddot{\text{Si}}^{\frac{1}{3}}$.

If we regard one-third of the peroxyd in Mr. Brush's analysis as replacing silica, the oxygen ratio for $\dot{\text{R}}$, $\bar{\dddot{\text{R}}}$, ($\dddot{\text{Si}}$) becomes 12·78 : 12·86 : 17·12, or between the bases and the rest 25·64 : 17·12= 3 : 2, giving the formula on page 129 of this volume

$$(\tfrac{1}{2}\dot{\text{R}}^{3} + \tfrac{1}{2}\bar{\dddot{\text{R}}})\,(\dddot{\text{Si}}, \bar{\dddot{\text{Al}}})^{\frac{2}{3}}.$$

* The mean from four analyses by Meitzendorf, from the 1st Supplement of Rammelsberg's Handw. Min., p. 158.

† Jour. für prakt. Chem., xli, 156.

ART. XLIV.—*Contributions to Mineralogy;* by Dr. F. A. GENTH of Philadelphia.

1. *Pyrophyllite.*

THIS interesting mineral was reported by Prof. C. U. Shepard to occur near Crowder's Mountain in North Carolina; the exact locality in that state is however "Cotton Stone Mountain," Mecklenburg county. My specimens from this locality were not pure enough for analysis; I give therefore in the following only the results of the examination of the same mineral from Chesterfield District, S. C.

B.B. it exfoliates into a fan-like opaque white mass of more than twenty times its original bulk; fuses with great difficulty into a white blebby slag. The lustre of the N. C. specimens is pearly; that of those from S. C. inclining to greasy.

The following are the results of my analyses:

Silica,	64·82	66·01
Alumina,	28·48	28·52
Sesquioxyd of iron,	0·96	0·87
Magnesia,	0·33	0·18
Lime,	0·55	0·23
Water,	5·25	5·22

2. *Chrysotile.*

The beautiful fibrous mineral of a yellowish white color and silky lustre, which occurs in small veins in serpentine at Abbottsville, N. J., has been examined by Mr. Edwin L. Reakirt.

B.B. it whitens, becomes brittle and fuses with difficulty into a white slag; with cobalt solution, flesh-colored. It contains:

Silica,	42·52	42·72
Alumina,	not det.	0·38
Sesquioxyd of iron,	not det.	0·30
Magnesia,	42·35	42·99
Water,	14·31	14·18

3. *Scolecite.*

Lyman Wilder, Esq., of Hoosick Falls, N. Y., kindly furnished me with the material for analysis of a mineral from the East Indies. It consisted of globular masses 5 to 6 inches in diameter of a radiated structure. Sometimes there was found between the radii, which have a vitreous lustre, the same mineral of a reticulated structure with pearly lustre.

B.B. it fuses with intumescence easily to a blebby glass. Mr. Wm. J. Taylor analyzed it and found it to contain:

Silica,	46·87
Alumina,	25·32
Lime,	13·80
Soda,	0·45
Potash,	0·13
Water,	13·46

4. *Owenite identical with Thuringite.*

In a previous paper (Am. Journ. Sc., 2d Series, vol. xvi, p. 165), I described a mineral from Harper's Ferry, Va., under the name "*Owenite*" as *new*, remarking, however, that the difference between it and Thuringite could be detected *only* by a chemical examination. I was unable at that time to obtain any genuine Thuringite for a comparative analysis, and, I must confess, I had *too much* confidence in Prof. Rammelsberg's analysis, to think it would need a repetition, since the difference was about 16 pr. ct. of alumina. In the meantime Prof. J. L. Smith, (Am. Journ. Sc., 2d Series, vol. xvi, p. 131), announced the identity of Owenite and Thuringite, but, the material for his analysis, as he told me, having been slightly altered by oxydation, it was desirable to reëxamine the fresh mineral. Jos. A. Clay, Esq., with the greatest liberality permitted me to take from his specimen a sufficient quantity for analysis. The original label of Dr. Krantz of Bonn, which was still with it, gave the locality "Schmiedeberg near Saalfeld in Thuringia." The material for the following analyses made by Mr. Peter Keyser, was not in the least degree altered, and the results, which he obtained show the identity in composition of Thuringite and Owenite, which latter name I therefore withdraw. For comparison I give besides the analyses of the Thuringite from Schmiedeberg also that of the same mineral from Harper's Ferry, Virginia (the Owenite).

	I.	II.	III.	IV.	V.
	From Schmiedeberg.				From Harper's Ferry. (Owenite.)
Silica,	24·36	23·09	23·19		23·21
Alumina,	15·69	15·86	15·34		15·59
Sesquioxyd of iron,	13·03	14·31	14·03		13·89
Protoxyd of iron,				34·20	34·58
Magnesia,	1·26	1·29	1·87		1·26
Lime,	0·00	0·00	0·00		0·36
Soda,	*trace*	*trace*	*trace*		0·41
Potash,					0·08
Water,				10·57	10·59

(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the so-called Benzoëoxyd and some other conjugate compounds.*—List and Limpricht have studied the crystalline body obtained nine years since by Ettling and Stenhouse by the dry distillation of benzoate of copper, and which has been supposed to have the formula $C_{14}H_5O_2$. The authors found for pure and well crystallized substances the formula $C_{13}H_5O_2$, which agrees well with the analyses of Ettling but not with those of Will, Stenhouse and Gerhardt. This formula being doubled becomes $C_{26}H_{10}O_4$ or $C_{12}H_5O+C_{14}H_5O_3$, and the reactions clearly shew that the body in question is really the benzoate of oxyd of phenyl. An aqueous solution of caustic potash does not decompose the benzoate of phenyl when boiled with it under atmospheric pressure, but when heated to 150°–170° in a closed tube with a concentrated solution of the alkali the benzoate is dissolved, and when the solution is saturated with sulphuric acid, benzoic acid separates and an oily body rises, easily recognized to be phenyl-alcohol or carbonic acid. An alcoholic solution of caustic potash readily decomposes the benzoate, yielding of course the same products. Heated in a closed tube with ammonia the benzoate yields benzamid and carbolic acid. Bromine acts readily upon the benzoate of phenyl yielding products of substitution in which 1, 2, and 3 equivalents of hydrogen are replaced by as many of bromine. Decomposition of these compounds with caustic potash proves that it is the hydrogen of the oxyd of phenyl alone which is replaced and not that of the benzoic acid. Chlorine acts in a similar manner. A cold mixture of 1 part of nitric acid and 2 parts of sulphuric acid converts the benzoate of phenyl into a yellow crystalline body in which 3 equivalents of hydrogen are replaced by 3 of NO_4: in this case, however, the decomposition with caustic potash shews that 1 eq. of hydrogen is replaced in the benzoic acid, and 2 eq. in the oxyd of phenyl. Setting out from the theory that many organic bodies now regarded as aldehyds, &c., are in reality ethers, and have twice the equivalent usually attributed to them, the authors point to the fact that Ettling's Parasalicyl is a compound of anhydrous benzoic and anhydrous salicylous acids, and further that oil of bitter almonds and cuminol are both ethers and not aldehyds, since the former yields with an alcoholic solution of potash, benzoic acid and benzoic alcohol; the latter cuminic acid and cuminic alcohol.—*Ann. der Chemie und Pharmacie*, xc, 190.

2. *Researches on different questions in Organic Chemistry.*—Strecker has communicated to the Academy of Sciences in Paris a memoir with this title, containing the solution of several important questions. We shall give the principle results of these investigations under separate captions.

Composition of tannic acid.—Strecker finds that pure tannic acid is represented by the formula $C_{54}H_{22}O_{34}$, and that in this formula 3 eqs. of water are basic, so that the anhydrous acid is $C_{54}H_{19}O_{31}$. The lead salts of tannic acid contain from 3 to 10 eqs. of oxyd of lead.

The combinations of tannic acid with sulphuric and chlorhydric acids mentioned by Berzelius are in reality mechanical mixtures and are not constant in composition. The splitting of tannic acid into gallic acid and glucose, discovered two years since by Strecker, may be represented by the equation $C_{54}H_{22}O_{34}+8HO=3(C_{14}H_6O_{10})+C_{12}H_{10}O_{10}$. Gallic acid, according to Strecker, is also a tribasic acid and is represented by the formula $C_{14}H_3O_7+3HO$.

Decomposition of brucine by nitric acid.—The action of nitric acid upon brucine has been studied by Laurent, Gerhardt, Liebig and Rosengarten, but the products of this action have never been satisfactorily ascertained. Strecker finds that these products are cacotheline, nitrite of methyl, oxalic acid and water. The reaction is represented by the equation

$$C_{46}H_{26}N_2O_8+5NO_5.HO=C_{40}H_{22}N_4O_{18}+C_2H_3O,\ NO_3+2C_2O_3,\ HO+4HO.$$

The constitution of cacotheline was determined by means of its platinum salt; Laurent assigned to it the formula $C_{42}H_{22}N_4O_{20}$.

Hydrocyanaldin.—When a mixture of aldehyd-ammonia, prussic acid and an excess of muriatic acid are allowed to stand for some days without heat no alanin is formed, but colorless crystals of a new body which Strecker terms cyanaldin, are deposited. It is neutral, insipid, insoluble in water, alcohol and ether; it fuses and sublimes at a moderate heat; potash decomposes it with evolution of ammonia. The formula of this body is $C_9H_6N_2$ or $C_{18}H_{12}N_4$; it does not appear to possess basic properties.

Production of propionic acid in fermentation.—In preparing lactic acid by the fermentation of sugar by Bensch's process, Strecker observed that when the temperature of the mixture was kept low for several months, large quantities of mannite were formed. A mixture which deposited crusts of lactate of lime was abandoned during several months in summer in a place where the temperature did not exceed 22° C., the water being renewed from time to time. The volatile acids formed being isolated proved to be propionic and acetic acids, both in very large quantity.

3. *On some combinations of hydrargyro-methyl and hydrargyrethyl.*—The researches of Frankland on the compounds of methyl and amyl with mercury are well known. Strecker has succeeded—and without any knowledge of Frankland's experiments—in preparing the corresponding compound of mercury and ethyl, by simply exposing a mixture of mercury and iodid of ethyl to diffuse light at ordinary temperatures. After some time, crystals are formed which increase till the whole liquid becomes solid. The crystals are readily recrystallized from boiling ether or alcohol, and separate in thin, colorless very brilliant laminæ. They sublime at 100° C., but fuse only at a higher temperature: they are insoluble in water but soluble without decomposition in ammonia and solution of caustic potash. The formula of these crystals is $C_4H_5 . Hg_2I$. The nitrate crystallizes in colorless prisms and is represented by the formula C_4H_5O, NO_5. The chlorid corresponds to the iodid. These compounds are all decomposed by light, which is the reason why Frankland could not obtain them.

Constitution of quinine.—Strecker has at length established the constitution of this important base, and finds it to be represented by

$C_{40}H_{24}N_2O_4$, which is precisely double the formula of Liebig. The nitrate is represented by the formula $C_{40}H_{24}N_2O_4, HO.NO_5$; the two sulphates are $C_{40}H_{24}N_2O_4, HO.SO_3$ and $C_{40}H_{24}N_2O_4, HO.SO_3 + HO, SO_3$. A mixture of iodid of ethyl and quinine dissolved in ether give crystals of iodid of ethyl-quinine or iodid of quinine in which 1 eq. of hydrogen is replaced by 1 eq. of ethyl; iodid of methyl produces a similar iodid of methyl-quinine; both these compounds are powerful bases. The author concludes that ethyl-quinine belongs to Hofmann's fourth class of bases and corresponds to ammonium NH_4. Quinine is itself a nitrid base or an ammonia, and contains in its molecule 3 compound radicals replacing hydrogen.

Artificial production of oil of cinnamon.—Strecker shewed some years since that styrone is the alcohol of cinnamic acid; he now finds that it may be readily transformed into its aldehyd by the action of air and platinum black. This aldehyd is pure oil of cinnamon.

Artificial production of taurine.—After several unsuccessful attempts, Strecker has succeeded in producing this remarkable body by heating isethionate of ammonia to a temperature of 230°, until the salt has lost 11 per cent. of its weight. The reaction is represented by the equation

$$NH_4O.C_4H_5O.2SO_3 = C_4H_7NO_6S_2 + 2HO.$$

The fused mass dissolved in water, precipitated by alcohol and then redissolved in water, gave large crystals identical with the taurine obtained from the bile.—*Comptes Rendus*, xxxix, 49, *July*, 1854.

4. *Contributions to the chemical history of Glucina.*—Weeren has published an investigation of glucina, which, although simply introductory to a more extended study of the salts of this metal, contains many interesting results. The author first examined the different methods which have been proposed for the separation of glucina from alumina. The result of this examination shewed that glucina cannot be completely separated from alumina either by means of carbonate of ammonia, caustic potash, sulphurous acid, or carbonate of baryta. Berzelius's method, by means of sal-ammoniac, is the only process which can be relied upon. In the execution of the separation by this method, however, the auther found it necessary to observe the following precautions. 1. To precipitate the two earths with ammonia after adding a very concentrated solution of sal-ammoniac. 2 To boil the mixture a long time. 3. To avoid too great an evaporation of the liquid. 4. To precipitate the glucina with sulphid of ammonium. The author considers the hydrate of glucina to be $G_2O_3 + 3HO$, though it is very readily decomposed, and loses a portion of its water at 110°, which renders its analysis very difficult. The numerous analyses of the carbonates of glucina lead to very improbable formulas, apparently either from their instability, or because the carbonates are mechanically mixed with variable proportions of hydrate. The sulphate of glucina has the formula $G_2O_3, 3SO_3 + 12HO$ as given by Awdejew; it loses 11 eq. of water between 100° and 110° C. but retains the 12th till a much higher temperature. The author has redetermined the equivalent of glucina by the careful analysis of the sulphate, and finds as a mean of five determinations the number 157·64, if we consider the glucina as GO, or 472·90 if we consider it G_2O_3. He prefers, however, the mean

between his own results and those of Awdejew, and considers therefore the equivalent of the metal 86·50—taking glucina as G_2O_3, or 57·68 taking glucina as GO.—*Pogg. Ann.*, xcii, 91. W. G.

5. *On a new Test for Zirconia;* by G. J. Brush, (J. f. pr. Chem., lxii, 7, 1854.)—In a recent examination of some American minerals, one of them regarded as rutile was decomposed by fusion with caustic potash, the fused mass dissolved in diluted hydrochloric acid, and the solution boiled with tin. Finding no reaction for titanium, the solution was tested with turmeric paper to ascertain whether it were alkaline or not. The paper was immediately colored orange-red. On dissolving a portion with still more acid, the same color was obtained, although with litmus paper the solution afforded an acid reaction.

On further analysis the mineral proved to be zircon, and it was found that the orange color was due to zirconia. To try the delicacy of the test, different zirconia minerals were examined, as zircons of Ceylon, the Ural and New York, Eudialyte, Wöhlerite and Catapleiite, and they all gave the orange color. Acid solutions containing the alkaline earths, alkalies, manganese, iron, zinc, tin, but not zirconia, were tested with turmeric paper, but no reaction was obtained except from a strong solution of sesquichlorid of iron, which in consequence of its own deep color discolored the paper. This may be avoided by reducing this chlorid to the protochlorid. An acid solution containing all but two of the above-mentioned substances, with a large excess of iron was reduced by tin. The solution gave no reaction with turmeric paper; but on adding a small portion of zirconia the color of the paper became orange-red. The presence of boracic acid wholly disguises that of zirconia. A known zirconia compound (a hydrate) was dissolved in hydrochloric acid and diluted with 3000 parts of water. The solution gave the deep orange-red color of zirconia; with 2000 parts more of water, the action was still distinct.

It appears therefore that turmeric paper is a simple and characteristic test of the presence of zirconia in an acid solution, when boracic acid is not present; if the solution is a very weak one, the paper should be left in it from half to one minute. It is to be observed that the solution should not be so acid that the acid itself will act on the paper and discolor it.

6. *On the Electricity of the Atmosphere;* by M. L. Palmieri, (Bib. Univ. Genève, xxvi, 1854, 105.)—M. Palmieri shows that the method of ascertaining the electrical condition of the atmosphere by the two ordinary methods, a fixed conductor, and a moveable electroscope (Peltier's method,) are unsatisfactory. The latter will often show indications when none is perceived with the former; and is also itself uncertain from difficulties of manipulating or the influence of the observer. M. Palmieri proposes therefore a new method by means of *a moveable conductor;* it is in use under the direction of the king of Naples at the Meteorological Observatory of Vesuvius at a height of 590 metres above the sea-level. The conductor extends above the roof of the building, and is arranged so as to be raised or depressed at will; its connections are of a nature to insulate it; and in the room below, it connects with an electroscope or other instruments as desired.

On elevating the conductor, the electric tension is measured by an electroscope; it is ascertained whether it be positive or negative by an electroscope of Bohnenberger; and in case of electricity in a dynamic state, a galvanometer may be connected with it by one wire whilst the other passes to the soil. An ordinary fixed conductor gives no indications if the earth and space about it are in equal electrical states, the condition then being one of equilibrium: But with Palmieri's arrangement, the conductor is raised, and the influence of the superior atmospheric beds become predominant; the electrometer will indicate tension according to the vertical distance passed through and the efficiency of the opposite electricities. Moreover the fixed conductor if there is much rain, is discharged as rapidly as the electricity is received; while the moveable conductor charges itself much more rapidly and gives decided indications.

M. Palmieri has ascertained some points of interest respecting atmospheric electricity.

He has verified on some serene days a diurnal periodicity in the electricity, as remarked by Schubler and others.

He finds that the interior even of storm clouds is always positive, except during the shock of lightning, or in the case of rain, hail or snow. In case of a rain storm commencing a long distance from the place of observation, and carried over this place by the wind,--he observes that when the storm is far off the electricity is positive, gradually increasing with the progress of the storm; when the storm comes near, the electricity is strongly negative, often producing sparks. When the rain has reached the place of observation, it is again positive; then strongly negative just after it passes, and finally positive, its usual condition. Between each period there is a momentary neutral point. The distance at which the rain begins to induce *negative* electricity is very variable, sometimes at 30 miles, and other times when the first drops begin to fall. The rain hence occupies a region charged with positive electricity surrounded by a zone of negative electricity. When there are several successive showers of rain, these results will be much complicated. Hence the idea of negative or neutral rain storms must be abandoned; negative clouds do not exist, and negative electricity is found in the atmosphere only in case of rain, hail or snow. During these three periods the effects are vastly the most energetic.

7. *A Vacuum made by Chemical means;* by M. C. Brunner.—The method is that by means of carbonic acid. The process is as follows: A tubulated bell glass is placed on a plate of ground glass, over a dish of sulphuric acid, above which acid on a support there is some quicklime; the bell glass is then filled through the tubulure with carbonic acid, the tube supplying this gas reaching to the bottom of the bell glass; after the atmospheric air is thus excluded, the tubulure is hermetically closed by a stopper through which passes a tube having a bulb containing water at the exterior end, while the interior extremity is near the lime. There is no action of the lime while it is dry, but on warming the bulb, water falls on the lime, and soon after, the carbonic acid is absorbed, while at the same time the moisture is taken up by the sulphuric acid.

Ammonia may also be employed, with some modifications of the process.—*Bib. Univ. de Gen.*, xxiv, 164.

II. Mineralogy and Geology.

1. *Contributions to Mineralogy;* by James D. Dana.—The following are figures of crystals of some species of American minerals.

Figs. 1, 2, *Compound Crystals of Copper Glance.* In fig. 1, composition is parallel to I, or the prism of 119° 35′; also parallel to $2\breve{i}$, producing thus a cruciform twin with the angle of intersection 125° 28′. In fig. 2, the composition is parallel to a face $\frac{1}{2}$, and the prisms cross at angles of 92° 5′ and 87° 55′.

Fig. 3, *Pyrites*, a crystal from Rossie, New York, in the cabinet of W. T. Vaux, Esq., of Philadelphia. The crystal is nearly an inch in diameter, and is peculiarly fine, although the surfaces, while very smooth, are not polished.

Fig. 4, *Mispickel* (Danaite). From a crystal in the cabinet of the late J. E. Teschemacher of Boston. It presents the unusual planes $1\bar{2}$, $\bar{3}$, and $3\frac{3}{2}$. It is from Franconia, New Hampshire.

Figs. 5, 6, *Quartz.* Figure 5 represents crystals from Quebec, furnished the author for examination by Mr. T. S. Hunt. They were from a half to three-fourths of an inch in length. The planes $-\frac{1}{2}$ are delicately etched, being covered with small triangular prominences, whose sides are parallel to the basal and two terminal edges of the plane $-\frac{1}{2}$. The other faces were shining. Other crystals from the same place were the inverse of that figured. Fig. 6 is taken from a slender crystal about one-eighth of an inch long, in the cabinet of J. E. Teschemacher. The narrow plane $-\frac{1}{2}$ instead of being plane, is excavated through its length with a neat triangular channel bordered by a sharp edge. The planes 22 and $3\frac{3}{2}$ are hardly separated by a well-defined edge, and are somewhat uneven in surface. The other planes are bright. The inclination of $\frac{8}{8}\frac{8}{8}$ on R gave on measurement 175°.

Figure 7, *Pyroxene.* A fine grass-green crystal an inch long with bright surfaces, from Long Pond, New York.

Figure 8, *Spodumene.* This is a new figure of the same crystal before roughly drawn by the author. The planes -22 and x appear to be hemihedral: but whether this is an accidental distortion or not is uncertain.

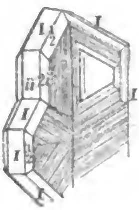
Figure 9, *Babingtonite?* The figure represents small polished black crystals occurring in mica slate at Athol, Massachusetts, referred to Babingtonite by Prof. C. U. Shepard. The form is triclinic, and the following are approximately the angles:

$O : I = 90°\text{–}91°$,	$I : I' = 110°\ 30'$ and $69°\ 30'$.
$O : I' = 85°$,	$I : i\breve{3} = 129°$.
$O : \frac{1}{2}' = 153°\ 20'$,	$I' : i\breve{3} = 120°\ 30'$.
$O : -1 = 135°\ 40'$,	$I : \frac{1}{2}' = 95°\ 30'$.
$O : 1 = 135°\ 30'$	$O : i\breve{3} = 95°\ 30'$.

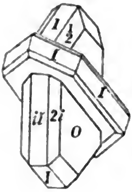
It resembles Epidote, and it is possible, that O, $\frac{1}{2}'$ and I', correspond respectively to O, $\frac{1}{2}i$ and $2i$ in Epidote.

Figure 10, *Zircon*, from McDowall Co., North Carolina. The crystals are found in the sands of the Gold region, and are seldom over a sixth of an inch in length.

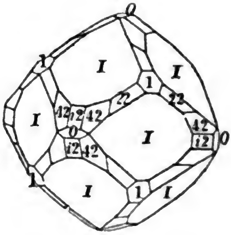
1.



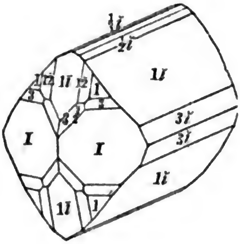
2.



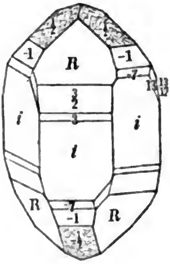
3.



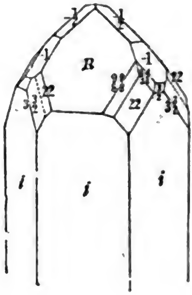
4.



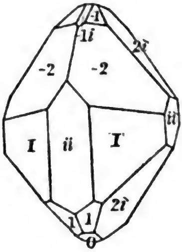
5.



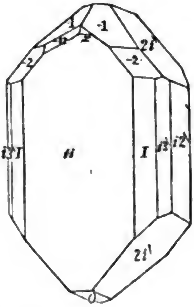
6.



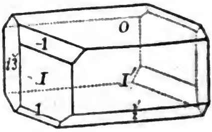
7.



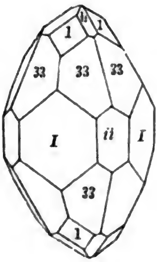
8.



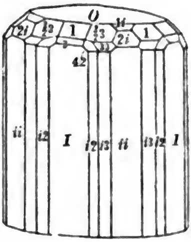
9.



10.



11.



12.

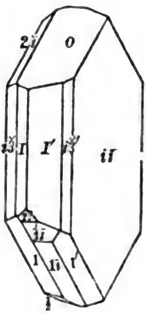


Figure 11, *Idocrase.* From a crystal from Sanford, Maine, furnished the author by L. Stadtmuller. It is nearly half an inch in diameter, and the faces are all bright. The Idocrase occurs massive or subcolumnar at that place, and there are often cavities of fine crystals. The crystals are sometimes thinly sprinkled over with dark green crystals of pyroxene, hardly a line long, which are loosely attached to the idocrase and are evidently of subsequent origin, apparently a result of its alteration. The crystals of idocrase undergo ready alteration, and often the surface peals off in layers, over the whole summit; and the alteration has proceeded inward with such exactness that the removed layer leaves behind the same number of small secondary planes as in the complete crystal, and all equally brilliant in polish. This is the more wonderful since there are no cleavages parallel to all or any of these small secondary planes. The color of the idocrase is brown and greenish-brown. In one specimen having a columnar structure, the columns along a straight line two inches in length met at an angle of 56° to 60°, indicating composition parallel probably to the plane $4i$.

Figure 12, *Albite* from the Middletown feldspar quarry. The crystals are half to one inch long, and in part transparent. They are mostly in twins parallel to $i\bar{i}$, but so united that the plane O and $1\bar{i}$ are in the same plane nearly. From one crystal the author obtained for $O : i\bar{i}$, 92° 40′ and 87° 20′.

Figure 13. The so-called *Loxoclase* from Hammond, St. Lawrence Co., N. Y., a feldspar shown by Smith and Brush to be orthoclase. The crystals are an inch long or larger, and of a nearly white color.

Figure 14. *Topaz* from Trumbull, Ct. The crystal is transparent and a fourth of an inch in diameter. The most of the terminal planes are rough.

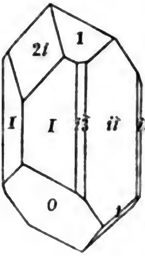
Figures 15, 16, 17, *Tourmaline.* Figure 15 represents an upper view of the termination of a slender transparent crystal of a light yellowish color, from London Grove, near Unionville, Pennsylvania. It is from the cabinet of T. F. Seal, of Unionville. Figure 16 is from a black crystal one inch in length from Northern New York. Fig. 17 is a brown tourmaline from Canada, received from T. S. Hunt of the Geological Commission, Canada. R is the rhombohedron of 103°.

Figure 18, *Apophyllite* from the Cliff mine, Lake Superior region, Michigan. The crystals are from one-fourth to half an inch in length and transparent. They are generally tabular, but occasionally octahedral. The plane $i3$ is not the prism usually noted on crystals of this species.

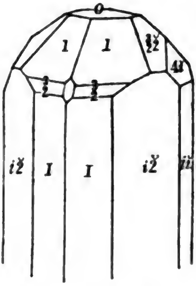
Figures 19, 20, *Barytes* or Heavy Spar.—Figure 19 represents a crystal from Cheshire, Conn.; figure 20, one from the Eldridge gold mine, Buckingham Co., Va., sent the author by Dr. F. A. Genth. The size varies between one-fourth and three-fourths of an inch. All the planes but the striated vertical planes are highly polished. The terminal face is often cavernous, the polished plane O being often finished at different elevations short of the actual summit of the crystal.

Figures 21, 22, 23, *Anglesite*, from different crystals from the Wheatley mine, Phœnixville, Pa., furnished the author by the proprietor, C. M. Wheatley. The crystals present the same planes nearly, but are elongated in different directions. They are brilliant, glassy, often transparent, and sometimes an inch or more in length.

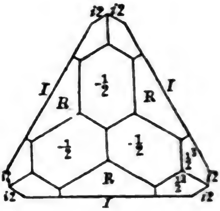
13.



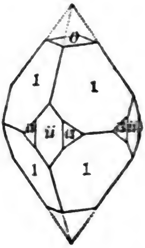
14.



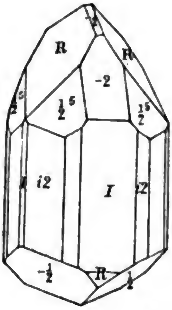
15.



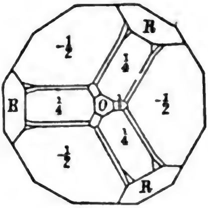
18.



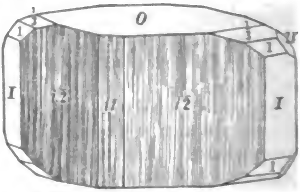
16.



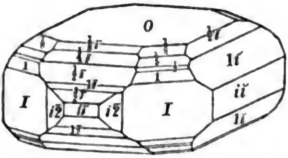
17.



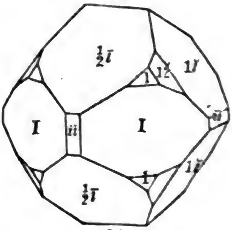
20.



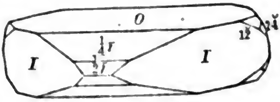
19.



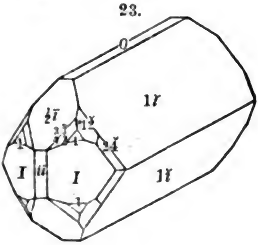
22.



21.



23.



24.

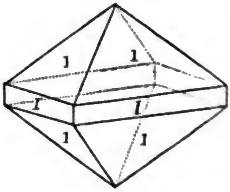


Figure 24. *Xenotime*, from Clarksville, Georgia, from crystals received from Prof. Lewis R. Gibbes, of Charleston, South Carolina.

25.

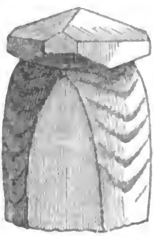


Figure 25. *Calcite.*—From the Copper mine, Bristol, Connecticut. The crystals are implanted thickly over the rock, and are about half an inch long. The six-sided prism after a gradually accumination to a three-sided summit by oscillation with a scalenohedral form, (probably 1^3,) is subsequently terminated by a crystal of the nail-head form, making literally a nail-head crystal. The planes of the summit are the rhombohedral $-\frac{1}{2}$R.

26.

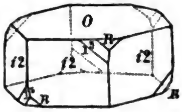


Figure 26. *Dolomite*, from Hoboken, New Jersey. The crystals are glassy, a third to a quarter of an inch across, and occur in cavities in massive dolomite.

2. *Beiträge zur Kenntniss der Eisenhohofen-Schlacken, nebst einem geologischen Anhange*, (on Iron Furnace Slags, etc.); by J. F. L. Hausmann. 102 pp. 8vo. (From Studien des Gött. Ver. Bergm. Freunde.) Göttingen, 1854.—Prof. Hausmann has contributed largely to our knowledge of the slags of furnaces, and presented the bearing of the subject on the origin of minerals. This recent paper contains descriptions and analyses of various furnace products, and an application of the facts to Geology.

(1.) *A slag called Kieselschmelz* (Siliceous Enamel).—This slag is described by M. Koch, (Beit. zur Kenntniss kryst. Hüttenprodukte, Göttingen, 1822, 8vo, p. 40–81). It occurs in 6-sided prisms, tabular or elongated, with the terminal edges sometimes removed, producing rarely a six-sided pyramidal termination. Color whitish, gray, yellowish, brownish, greenish. G.=2·72. H.=·7. Translucent, to subtranslucent. Lustre waxy, weak. Crystals sometimes glassy at centre.

Analyses of specimens from iron-furnaces: 1, 2, by A. Knop, different specimens of same slag from the Hartz; 3, Dr. Limpricht, another slag from the Hartz; 4, Knop, from Neuwerk, of the Brunswick Hartz:

	1.	2.	3.	4.
Silica,	55·78	59·45	54·27	55·41
Alumina,	15·28	15·43	9·40	11·52
Lime,	29·21	25·12	29·30	28·10
Magnesia,	——	——	1·15	1·89
Protox. iron,	—— =100·27	—— =100	6·58=100·70	3·08

Analyses 2, 3, and 4, give for the oxygen ratio of $\dot{R}$, $\bar{R}$, $\dddot{Si}$,

2,	7·18 : 7·21 : 31·50 = 1 : 1 : 4 (nearly).
3,	10·29 : 4·39 : 28·75 = 2·34 : 1 : 6·55
4,	9·47 : 5·38 : 29·20 = 1·76 : 1 : 5·43

These ratios afford for the oxygen of all the bases and the silica the ratio nearly of 1 : 2, which is characteristic of both pyroxene and beryl; Hausmann deduces the formula $\dot{C}a^3 \dddot{Si}^2 + \bar{A}l \dddot{Si}^2$, and points out the close similarity to beryl, if glucina be taken as a protoxyd, the difference

being that lime here replaces the glucina. Analysis 2 affords very nearly this formula.*

The form is related to that of beryl. The inclination of the pyramidal planes on the lateral faces of the hexagonal prism according to Koch is 103° 15′ 46″, or on *O* (the base) 166° 44′ 14″. This plane referred to the beryl type is, the plane $\frac{2}{3}$.†

(2.) *Gehlenite Slag.*—Among the slags of iron furnaces, 4-sided rectangular prisms or tables are not uncommon. D. Forbes first pointed out a slag in 4-sided prisms which was near Humboldtilite. Hausmann has described similar slags. Rammelsberg refers a slag from Oldbury, England, described by Percy, to Gehlenite, it giving the composition $3\dot{R}^3\,\dddot{Si}+\dddot{\bar{Al}}^3\,\dddot{Si}$. A slag from near Homberg, analyzed by Bunsen has a similar constitution. It occurs in tabular or oblong prisms, of a pearl gray color, glassy or pearly lustre, sometimes translucent; G.=2·876, H.=6. B.B. in the forceps fuses with some difficulty to a grayish slag. Bunsen's analysis afforded

$\dddot{Si}$	$\dddot{\bar{Al}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Mn}$	$\dot{K}$	$\dot{Na}$
32·22	17·81	17·35	5·57	2·67	3·05	11·30=99·97

whence the formula $2\dot{R}^3\,\dddot{Si}+\dddot{\bar{Al}}^2\,\dddot{Si}$.

Rammelsberg has analyzed and described some slags from Mägdesprung in the Anhalt Hartz,‡ where the ores are spathic and specular iron and limonite. He obtained for the formula $\dot{R}^8\,(\dddot{Si},\dddot{\bar{Al}})^2$, adopting Scheerer's view that $3\dddot{\bar{Al}}$ replace $2\dddot{Si}$. This is similar to some aluminous pyroxenes. The crystallized and glassy slags gave the same composition. Both dimetric (Humboldtilite-like,) and augitic crystallizations occur at Mägdesprung, and it appears probable that the two are a case of dimorphism. Von Kobell formerly wrote for the formula of Gehlenite $\dot{R}^3\,(\dddot{Si},\dddot{\bar{Al}})^2$; and this is analogous to the formula of pyroxene.§

* The special formula above given is correct only for analysis 2. The general formula for the whole may be written $(\dot{R}^3,\dddot{\bar{R}})\,\dddot{Si}^2$, with which the results accord very closely, as Hausmann shows. It is the formula of the Augite Section of Silicates, and includes pyroxene and beryl, these species being dimorphous. The slags are very near *Wichtyne* in composition, which the writer has placed in the Augite Section and may be the same species; the formula for Wichtyne is the same as for No. 2, viz. $\dot{R}^3\,\dddot{Si}^2+\dddot{\bar{R}}\,\dddot{Si}^2$; it differs mainly in containing protoxyd of iron in place of lime. The slags may therefore afford evidence that *Wichtyne* is hexagonal in crystallization.—J. D. D.

† It is also of interest to compare the form with that of Nepheline. In Nepheline O : ½ = 166° 25½′, which differs 18½′ from the inclination of the pyramidal plane in the slag. It may be also noted that O : ½2 in beryl is 165° 59½′.—J. D. D.

‡ Poggendorff's Annalen, 1848, lxxiv, 95, and Lehrbuch der Chem. Metallurgie.

§ The analyses of the Mädgesprung slags by Rammelsberg gave rather varying ratios. The per-centage of silica was about 40; and the ratio between the oxygen of all the bases and that of the silica, was nearly 3 : 4, instead of 6 : 4, the Gehlenite ratio. Rammelsberg deduces for the ratio between the oxygen of the protoxyds and that of the silica and alumina ($3\dddot{\bar{Al}}$ replacing $2\dddot{Si}$), 1 : 1·7, to 1 : 2·0; 1 : 1·83 is the mean of his results. For his formula, 1 : 2 is taken as the ratio.

Gehlenite has the oxygen ratio for $\dot{R}$, $\dddot{\bar{R}}$, $\dddot{Si}$, 3 : 3 : 4, which gives 6 : 4 or 3 : 2 for the oxygen of the bases and silica; while Humboldtilite has the oxygen ratio 6 : 3 : 9, corresponding to 1 : 1, between the bases and silica, thus differing widely from Gehlenite. The formula of Gehlenite based on the ratio 3 : 2 would be

$(\frac{1}{2}\dot{R}^3+\frac{1}{2}\dddot{\bar{R}})\,\dddot{Si}^{\frac{2}{3}}=\dot{R}^3\,\dddot{Si}^{\frac{2}{3}}+\dddot{\bar{R}}\dddot{Si}^{\frac{2}{3}}$, and that of Humboldtilite $(\frac{2}{3}\dot{R}^3+\frac{1}{3}\dddot{\bar{R}})\,\dddot{Si}=2\dot{R}^3\,\dddot{Si}+\dddot{\bar{R}}\,\dddot{Si}$.

There is as yet no good evidence that alumina replaces silica in Gehlenite. Pyroxene, Humboldtilite and Gehlenite appear rather to belong to different sections of silicates, the first, to the Augite, the second, to the Garnet, to which Scapolite pertains, and the third, to the Andalusite section.—J. D. D.

(3.) *Pyroxene Slag from Stolberg in the Hartz.*—The slag is part glassy and part enamel-like. The crystals are yellowish-white, with the lustre weak resinous; they are either 4 to 6-sided prisms or oblique octahedral. The form may be referred to the Augite type. The occurring vertical prism has the angle 115°, corresponding to $i\frac{5}{3}$ (∞ P$\frac{5}{3}$) of pyroxene. Analysis afforded M. Levi:

$\dddot{\text{Si}}$	$\overline{\text{Al}}$	$\dot{\text{Fe}}$	$\dot{\text{Mn}}$	$\dot{\text{Ca}}$	$\dot{\text{Mg}}$	$\dot{\text{K}}$	S
42·75	9·09	2·77	4·64	38·19	0·74	0·39	0·78=99·30

Taking 3$\overline{\text{Al}}$ as replacing 2$\dddot{\text{Si}}$, as Hausmann states, the oxygen ratio for the protoxyds and silica is nearly 1 : 2. The slag is related to those examined by Rammelsberg from Mägdesprung.

(4.) *Feldspar Slag from near Stolberg in the Hartz.*—This slag has a gray color and is part blebby and part crystalline. The crystalline slag has a massive base through which crystals are disseminated. The crystals are thin, long prisms, (about a line thick) and they appear to have a rectangular cleavage; color white, with a resino-vitreous lustre; G.=2·35; H.=6. B.B. fuses rather easily with much intumescence to a white translucent blebby glass. Insoluble in muriatic acid. Analysis gave:

$\dddot{\text{Si}}$	$\overline{\text{Al}}$	$\dot{\text{Fe}}$	$\dot{\text{Mn}}$	$\dot{\text{Ca}}$
66·2	10·4	1·9	0·1	21·0 = 99·6

giving the oxygen ratio for $\dot{\text{R}}$, $\overline{\text{R}}$, $\dddot{\text{Si}}$, 6·44 : 4·86 : 35·07, which Hausmann observes corresponds nearly to $\dot{\text{R}}\,\dddot{\text{Si}} + \overline{\text{Al}}\,\dddot{\text{Si}}^3$, the formula of Orthoclase, from which it differs in containing lime in place of potash.*

(5.) *On the blue color of glassy slags.*—The author adopts the view of Fournet (Ann. des Mines, [4], ii, 57), that the cause of the blue color is not chemical. The green color of bottle glass changes to blue as the glass begins to pass to the condition of enamel or an earthy state; and the color is produced in this incipient stage by a new grouping of the minute particles of the mass. Another kind of blue slag, having lavender-blue to ultramarine or indigo-blue color, is supposed to derive its color (like ultramarine) from the presence of a trace of sulphur, as found on analysis.

After an enumeration of the crystalline silicates in slags, (1, Pyroxene species; 2, Gehlenite; 3, Humboldtilite; 4, Feldspar; 5, Chrysolite; 6, Beryl-like; 7, Chytophyllite,)† the author reviews the characters of the different varieties of slags, which he divides into, (I) the Crystalline Slags; II, Porcelain and Stony Slags; III, Glassy Slags; IV, Porphyritic (1, with the base crystalline; 2, with a porcellanous or stony base; 3, with a glassy base); V, Variolite Slag; VI, Blebby and Scoriaceous Slags; VII, Filamentous Slag; VIII, Capillary Slag; IX, Pseudomorphous Slag.

* This formula corresponds to the oxygen ratio 1 : 3 : 12, while the slag gives 1 : 0·75 : 5·45. The two are nearly alike in having for the oxygen ratio of the bases and silica 1 : 3. But from the shape of the crystals, the absence of the feldspar-habit, as well as the divergence from the feldspar oxygen ratio between the protoxyds and peroxyds (1 : 3), it seems probable that the slag is more nearly related to Edelforsite ($\dot{\text{Ca}}\,\dddot{\text{Si}}$ or $\dot{\text{Ca}}^3\,\dddot{\text{Si}}^2$) than to Feldspar. The formula may be ($\dot{\text{Ca}}^3$, $\overline{\text{Al}}$) $\dddot{\text{Si}}^3$, analogous to that of Edelforsite, in which $\dot{\text{C}}^6$ is to $\overline{\text{Al}}$ as 4 : 3.—J. D. D.

† See a notice of Hausmanu's descriptiou of this species iu this Journal, vol. xii, p. 394.

Hausmann next compares the specific gravity of certain slags in the stony and glassy states. He then proceeds to apply the subject to Geology, comparing the furnace products with volcanic ejections and other igneous rocks. The minerals of slags, pyroxene, chrysolite, feldspar, humboldtilite, are observed to characterise the Vesuvian lavas. He distinguishes between the volcanic, vulcanoidic and Plutonic rocks, the last never running into glassy forms and abounding in silica; the second kind an intermediate class between the volcanic and the Plutonic.

3. *Temperature of the interior of the Earth.*—An artesian well has been dug at Naples at the Royal Palace under the direction of MM. Melloni and Cangiano. The opening is about 20·98 meters above the level of the sea. After descending 15·2 meters, a volcanic tufa was reached which was 84 meters thick; at the end of December, 1845, they had gone beyond this 60 meters through different imperfectly aggregated volcanic materials, below which the engineer Cangiano expected to find the Jurassic formation, which extends from the Promontory of Castellamare and Nocera. M. Melloni ascertained that the temperature varied from 14°·6 to 15°·5 C. (58·3 to 60° F.) at 30 meters below the surface. It was 18°·3 C. (65° F.) at a depth of 190 meters, which gives an increase of 1° C. for 50 meters (or 1° F. for about 30 yards), a slower rate of increase than has elsewhere been observed, which Melloni attributes to the poor conductibility of volcanic tufa for heat. In a well sunk in the Tuscan marshes, the increase of temperature was 3 times more rapid.—*Atti del Instituto Veneto*, v, 234–237, and *Bib. Univ. de Genève*, *June*, 1854, 177.

4. *A System of Mineralogy, comprising the most Recent Discoveries:* including full Descriptions of Species and their Localities, Chemical Analyses and formulas, Tables for the Determination of minerals, with a Treatise on Mathematical Crystallography and the Drawing of Figures of crystals. Illustrated by six hundred wood-cuts. By James D. Dana, Fourth edition, rewritten, rearranged and enlarged. 2 vols., 320 and 534 pp. 8vo. New York and London: Published by George P. Putnam & Co. 1854.—As a notice of the new edition of this work we cite here the Author's Preface.

In the Preface to the last edition of this Treatise, the classification of Minerals then adopted was announced as only a temporary expedient. The system of Mohs, valuable in its day, had subserved its end, and in throwing off its shackles for the more consistent principles flowing from recent views in chemistry, the many difficulties in the way of perfecting a new classification led the author to an arrangement which should "serve the convenience of the student without pretending to strict science."

A classification on chemical principles was however proposed in the latter part of the volume, in which the Berzelian method was coupled with crystallography, in a manner calculated to display the relations of species in composition as well as form, and prominently "exhibit the various cases of isomorphism and pleomorphism among Minerals." The progress of Science has afforded the means of giving greater precision and simplicity to this arrangement, until now it seems entitled to become the authorized method of a System of Mineralogy. Whether regarded from a physical or chemical point of view, the groupings ap-

pear in general to be a faithful exhibition of the true affinities of the species.

The mind uneducated in Science may revolt at seeing a metallic mineral, as galena side by side with one of unmetallic lustre, as blende; and some systems, in accordance with this prejudice, place these species in separate orders. Like the jeweller, without as good reason, the same works have the diamond and sapphire in a common group. But it is one of the sublime lessons taught in the very portals of Chemistry, that nature rests no grand distinctions on lustre, hardness, or color, which are mere externals, and this truth should be acknowledged by the Mineralogist rather than defied. Others, while recognizing the close relations of the carbonates of lime, iron, zinc and manganese, (calcite, spathic iron, smithsonite and diallogite,) or of the silicates of lime, iron, manganese, (wollastonite, augite, rhodonite,) are somewhat startled by finding silicate of zinc, or silicate of copper among the silicates of the earths or of other oxyds. But the distinction of "useful" and "useless," or "ores" and "stones," although bearing on "economy," is not Science.

The advantages which the arrangement of the last edition afforded those interested in mining and metallurgy, is secured in the present volumes by an index to the useful ores, in which their distinctive characters and their relative importance in the Arts are mentioned, and references are given to the pages where the full descriptions are to be found.

During the four years since the appearance of the last edition, the Science of Mineralogy has increased in species from 625 to 660; and this notwithstanding the bankruptcy of some 45 of the number. The important work of Rammelsberg on Chemical Mineralogy, has been continued in a fifth Supplement, issued in 1853. A similar review of the Progress of the Science by Dr. Gustav Adolph Kenngott, conducted with like thoroughness, though with less criticism, has appeared in Vienna, and already two large volumes have been issued, one reviewing the Science for the years 1844 to 1849, the other, for 1850 and 1851. During this period also, Professor Gustav Rose has published his Krystallo-chemische Mineral-System (1853); Professor von Kobell, a work on Mineralogical Nomenclature (1853), and a new edition of his excellent Tables for the Determination of Minerals, (1853); Dr. Franz Leydolt and Professor Adolf Machatschek, of Vienna, their Elements of Mineralogy based on the system of Mohs (1853); Dr. Kenngott of Vienna, "Das Mohs'sche Mineralsystem" (1853), and also a portfolio of plates of figures for the construction of Models of crystals (1854); Professor Quenstedt, of Tubingen, the first part of a Treatise on Mineralogy (1854); Dr. C. F. Naumann, a revised edition of his invaluable Elements of Crystallography (1854); Dr. Friederich Pfaff, of Erlangen, Elements of the Mathematical Relations of Crystals (1853); F. H. Schröder, of Clausthal, Dr. Rammelsberg of Berlin, and Jos. Pecirka of Prague, smaller Manuals on the same subject, (1852, 1853); Dr. J. Zimmermann of Stuttgard, a small "Taschenbuch der Mineralogie" (1852); Nicolai von Kokscharov, the able Crystallographer of St. Petersburg, the first numbers of his "Mineralogie Russlands," in quarto, (1853, 1854); H. J. Brooke and W. H.

Miller, a new and original Treatise under the title of Phillips's Mineralogy (1852); C. F. Plattner, an enlarged edition of his extended Treatise on the Blowpipe (1853): besides the great work of Dr. Gustav Bischof, on Chemical and Physical Geology, begun in 1846, now numbering 2950 pages, (the last issue in 1853), and yet wanting another part to be complete; also G. H. Otto Volger's Essays on the Development of Minerals, (Studien zur Entwicklungsgeschichte der Mineralien,) as the basis of Scientific Geology and a rational Mineral Chemistry, (Zürich, 1854); and von Waltershausen's Treatise on the Volcanic Rocks of Sicily and Iceland. Moreover, various valuable papers have been issued in Scientific Journals and Transactions abroad, by Haidinger, Rammelsberg, Breithaupt, Scheerer, von Kobell, Rose, Bunsen, Hermann, von Rath, Hausmann, Sandberger, Wöhler, Baer, Kenngott, Schabus, Kokscharov, Scacchi, Meneghini, Delesse, Damour, Deville, Descloizeaux, Senarmont, Chapman, Mallet, Scott, Percy, and other able investigators. In this country have appeared Part I. of the third edition of Prof. C. U. Shepard's Mineralogy (1852); Foster & Whitney's Report on the Geology and Mineralogy of the Lake Superior Region (1851 and 1853); and J. D. Whitney's Mineral Wealth of the United States (1854).* Moreover, Dr. J. Lawrence Smith and G. J. Brush, have labored with important results in American Mineralogy, clearing away many doubtful species; and other researches have been published by T. S. Hunt, F. A. Genth, J. C. Booth, J. D. Whitney, C. U. Shepard, J. W. Mallet, W. P. Blake, M. H. Boye and T. H. Garrett.

Of all these publications, Bischof's "Lehrbuch" stands first in importance. Mineralogy was well nigh a lifeless Science, having only powers of increase by accretion, like the objects of which it treats,—the addition of a new Mineral now and then being the great event of interest in its progress. Bischof, by his elaborate researches and profound views, has given it a new impulse. He makes every analysis of a Mineral an important element in the study of Mineral history, showing the necessity of their multiplication, and well exposing the leanness of Chemical formulas when given as a substitute for analyses. The associations and collocations of Minerals, their changes from exposure to atmospheric and other agencies, and even the infinitesimal ingredients in their constitution, are all made to bear on the question of the origin and progress of Mineral and Rock Formations. A Mineral species is shown to have a history of its own,—its perfect state, its liabilities to alteration and decay, its successive changes, and again its renovation or its metamorphosis into a new species. These views taken in their wide extent, constitute the proper basis of the Science of Geology, and should have their full exposition in a work on that Science. But the elements of the subject are with propriety indicated in a Mineralogical Treatise. While dwelling with deserved emphasis on the researches of Bischof, we should not forget that others have labored in the same department, prominent among whom, are Haidinger, Volger, Breithaupt, Blum, Bunsen and Delesse.

* Logan's Reports on the Geology of Canada, 1849–1853, should here be added, as they contain much that is valuable in Mineralogy as well as Geology.

The work next in importance, more especially in its bearing on the crystallization of Minerals, is the "Elementary Introduction to Mineralogy," by Brooke & Miller. It stands preëminent for its original measurements, and its thorough revision of the angles of Crystals, and will remain a permanent source of information on these points.

In the preparation of the present edition, the author takes pleasure in making special acknowledgements to the work of Bischof, for facts and principles relating to the Chemistry of the alteration of Minerals; to Rammelsberg's Supplement to his Chemical Mineralogy, a work whose earlier parts contributed largely to the preceding edition of this Treatise; to Kenngott's and Kokscharov's publications; and to the critical observations in the "Mineralsystem" of G. Rose. Frequent use has also been made of the work of Brooke & Miller, in the crystallography of the species, from which the angles and planes of crystals have often been cited. The various Scientific Periodicals of Russia, Germany, Italy, France and Britain, some of them down to June last, have been searched for their facts, and every effort has been made to post the work up to the day of publication.

American Mineralogy owes much to the careful revision it has received at the hands of Messrs. Smith & Brush; and the author would express his special personal obligations to each of these Chemists. From Dr. F. A. Genth, of Philadelphia, he has derived generous aid both in suggestions and results of researches. Mr. T. S. Hunt has kindly contributed several new analyses throwing much light on the minerals of Canada; and valuable observations and analyses have been received from J. D. Whitney and Professor Booth. Many and various have been the favors, in the way of new facts, opinions and recent discoveries, which the author owes to Mr. Louis Sæmann of Paris. He is also largely indebted to Robert P. Greg, Jr., of Manchester, England, for information respecting the Mineralogy of Great Britain, liberally furnished from a work by him and W. G. Lettsom, now in the press. * * * *

In the preparation of this edition, the subject of Crystallography has been revised and simplified. A system of notation for the figures of crystals, both brief and simple, has been adopted; and many new and original figures have been introduced. The homœomorphous relations of mineral species have been worked out with considerable care, in order to arrive at their true fundamental forms, and trace the bearing of the subject on their composition and classification. The Table of atomic weights has been corrected according to the most recent results, and the percentages of the formulas have been recalculated to correspond with it. The subject of pseudomorphs is treated at some length, and along with the descriptions of the species, a paragraph is devoted to the altered forms which each presents. These changes, together with the remodeling of the classification, and the large additions throughout, render the Treatise more properly a new work, than a revised edition.

5. *Lanthanite.*—Prof. J. Lawrence Smith, as an addition to his account of this species, on page 378, mentions that the specific gravity is 2·843, a little higher than the determination of W. P. Blake. Prof. Smith freed the mineral from air by boiling it and then using the air-pump.

III. Botany and Zoology.

1. *Victoria Regia; or the Great Water Lily of America; with a brief account of its discovery and introduction into cultivation; with illustrations by William Sharp, from specimens grown at Salem, Massachusetts, U. S. A.;* by John Fisk Allen. Boston, 1854.—This regal Water-Lily, whose gigantic size baffles the ordinary resources of the cultivator, was, as is well known, first raised and flowered in this country by Caleb Cope, Esq., of Philadelphia, who, aided by our sunnier climate, succeeded in giving the plant an ampler development than it had attained in England. Mr. Allen of Salem, a gentleman of great enthusiasm and success in cultivation, has the honor of having followed this example, and of flowering the *Victoria* last summer, for the first time in New England. By a skillful arrangement, Mr. Allen was able to bring the plant to great perfection in a tank of moderate size, the borders of which were enlarged from time to time as the successive leaves increased in magnitude. This year new plants have been raised in an ample tank constructed for the purpose, and already its huge blossoms are beginning to appear. Not content with thus rivalling the royal and princely conservatories of Kew, Syon, and Chatsworth, in the cultivation of the great Water Lily of the Amazon, Mr. Allen has now emulated Sir Wm. Hooker's magnificent work, illustrating the *Victoria* by colored figures mostly of the natural size, and in the highest style of art. Mr. Allen's treatise is an equally sumptuous work, of about the same gigantic size, the largest elephant folio, and the paper, typography and colored plates will compare favorably with the English work, except in the want of botanical details and dissections. Unsparing of expense, Mr. Allen has given six plates; while Sir Wm. Hooker has only four. And in 16 pages of text of the same huge dimensions, Mr. Allen has given a condensed abstract of the botanical history of the plant and of its introduction into cultivation in England, followed by a more detailed account of its cultivation into this country by Mr. Cope and himself, and a description of all its parts, as exhibited in the individual under his attentive observation. A. G.

2. *Plantæ Junghuhnianæ: Enumeratio Plantarum quas in Insulis Java et Sumatra detexit Fr. Junghuhn.* Fasc. III. (Leyden, 1854. pp. 271–394. 8vo.)—The excellent Dutch botanists are now very active, especially Prof. Miquel, Prof. De Vriese (who is still occupied with the elaboration of the Laurineæ for De Candolle's Prodromus), and Drs. Dozy and Molkenboer, who have worked up the *Musci Frondosi* (the Div. *Acrocarpi*) of Junghuhn's collection in the present fasciculus. Some new collaborators appear in the work: Among them M. Buse, who has elaborated the *Gramineæ*, and proposed several new genera; and Dr. Bruyn, who has given the *Polygonaceæ*. There are also the *Lycopodineæ* by Spring, and several small orders by Miquel. A. G.

3. *Steudel's Synopsis Plantarum Glumacearum:* fasc. III. comprises most of the *Agrostideæ* (with 171 species of Agrostis!), the *Arundinaceæ*, *Pappophoreæ*, *Chlorideæ*, and the greater part of the *Avenaceæ*. The work will be useful as bringing together the vast number of Grasses published since Kunth's Enumeration; but is of no more critical value than that work. A. G.

4. *Seemann's Botany of the Voyage of the Herald.*—Part V, finishes the *Compositæ* of the Flora of the Isthmus of Panama, and continues this flora down to the *Piperaceæ*, which, as well as the *Artocarpeæ*, are elaborated by Professor Miquel of Amsterdam, the able monographer of these families. Mr. Seemann has reëstablished the order *Crescentiaceæ*, with a new character, and referred to it nine genera and about thirty known species; all natives of tropical and subtropical America and Africa. His views were expounded last winter in a paper read before the Linnæan Society of London, when he divided the order into two sections, the *Crescentieæ* and the *Tanæcieæ*. In the September No. of Hooker's Journal of Botany, this author has given an able revision of the principal genera and species of the *Crescentieæ*. Among the plates are fine illustrations of the Ivory-Nut Palm, the *Phytelephas macrocarpa* of Ruiz and Pavon. A. G.

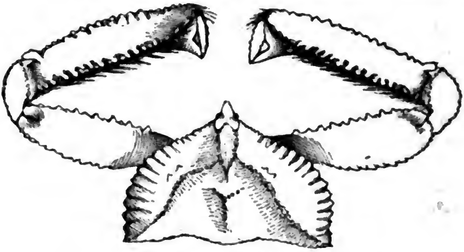
The *Pandaneæ*, or Screw Pines, are being investigated by Professor De Vriese of Leyden, who is about to publish Nova Genera Pandanearum, with illustrations. Meanwhile, some remarks on the family, and characters of two new genera, read before the Academy of Sciences at Amsterdam, are published in Hooker's Journal of Botany for September. A. G.

Three Botanists of considerable distinction have died during the past summer, namely, Dr. Fischer of St. Petersburgh, long the Director of the Imperial Botanic Garden, who deceased on the 5th of June, aged 73. M. Moricand of Geneva, the author of *Plantes Nouvelles d'Amérique*, also well known as a conchologist; he died June 26th. Philip Barker Webb, Esq., a distinguished English Botanist, long resident abroad, chiefly in Paris, where he will be greatly missed and deeply regretted, not only by all the French Naturalists, but by a wide circle of friends and correspondents, who will long remember his generous hospitality and kindness. He died suddenly, of cholera, on the 31st of August. Mr. Webb was an excellent classical scholar as well as a general naturalist. His most extensive work is the *Histoire Naturelle des Iles Canaries*, written in conjunction with M. Berthelot; almost every page of which reveals something of the vast and varied knowledge of Mr. Webb. Among his publications are the *Otia Hispanica*, a folio volume of plates and descriptions of Spanish plants; the *Spicilegia Gorgonea*, an account of the botany of the Cape de Verd Islands, contributed to Hooker's Niger Flora; and the *Fragmenta Florulæ Æthiopico-Ægyptianæ*, recently published. Mr. Webb had accumulated one of the largest private herbaria in the world. This, we learn he bequeathed to his "dear friend, the Duke of Tuscany." Its acquisition will render the Florentine herbarium,—the foundation of which was recently laid by his friend, the zealous Parlatore—one of first-rate importance.

To this list should be added the name of the late King of Saxony (recently killed by a fall from his carriage), one of the Foreign Honorary Members of the Linnæan Society of London, a botanist of much zeal and no mean acquirements. A. G.

5. *Description of a New Species of Cryptopodia from California*; by James D. Dana.

Cryptopodia occidentalis. Rostrum parvulum, subspiniforme. Carapax postice rectangulatus, angulis postero-lateralibus acutis, margine postico rectiusculo, transverso, margine antero-laterali arcuato, lateralique denticulatis. Chelæ prælongæ, bene trigonæ, angulis tenuibus inæquè subspinulosis, manu latitudinem carapacis longitudine æquante, superficie supernâ planâ. Pedes 8 postici tenuiter compressi, articulis 3tio 4to 5toque bialato, tarso tenui, 4-alato. Long. 1″.



Cryptopodia occidentalis.

The carapax has a triangular sharp-edged prominence on the medial line behind the middle; a doubly curving subtuberculate ridge extending to the posterior angles; a small denticulate ridge, extending from near the middle to either side of the base of the beak, the two enclosing a narrow area. The breadth of the carapax is 1¼ inches, the length of the hand 1⅜ in.; of the carpus 5 lines; of the arm 1 inch. The animal appears to have had when alive a villous coat over the carapax and upper surface of the hand. From Monterey, where it was obtained by Wm. Rich, Esq.

IV. Astronomy.

1. *New Planets*, (Astron. Journ., 75.)—Mr. J. R. Hind announces the discovery of another asteroid, on the 22d of July, at $11^h\ 25^m$, at Mr. Bishop's Observatory in Regent's Park. It appears as a star of the 9·10 magnitude. Its position at that time was R. A. $21^h\ 10^m$ and N. P. D. 106° 20′. On the 1st of Sept., Mr. James Ferguson of the Washington Observatory discovered a new asteroid near *Egeria*, and nearly equaling it in brightness. The next day it preceded *Egeria* 24^s, and was 52″ farther North. Professor Reuel Keith has computed the following elements from the Washington observations of Sept. 2, 6, and 10. They satisfy the middle place perfectly.

Mean Equinox 1854.0 Epoch, Sept. 2·721 Greenwich M. T.

Mean anomaly, - - - - - -	13° 36′ 33″·3
Long. perihelion, - - - - -	352 5 50 ·6
" asc. node, - - - - -	33 29 21 ·7
Inclination, - - - - - - -	22 39 13 ·6
Angle of excentricity, - - - -	4 22 30 ·2
Log. semi-axis major, - - - - -	0·469530
" mean daily motion, - - - -	2·845712

2. *New Comet*, (Astron. Journ., 76.)—A new comet was discovered on the 13th of Sept. by Mr. Robert Van Arsdale at Newark, N. J. Its position, Sept. 3d, $9^h\ 50^m\ 30^s$ was R. A. $8^h\ 21^m\ 36^s$, and Decl. +74° 30′.

V. Miscellaneous Intelligence.

1. *Correspondence of M. Jerome Nicklès, dated Paris, Sept.* 2, 1854.

Death of Dr. Lallemand and of Melloni.—Science has experienced a great loss in the deaths of Dr. Lallemand and the Physicist Melloni. The former died at the age of 65 years, leaving a great void in medico-chirurgical science, of which he was one of the most illustrious representatives. Melloni died suddenly from an attack of cholera, when he was just giving his last stroke to a work on electrostatic induction. His death took place on the 7th of August, while he was living on a small farm where he had retired since the king of Naples had taken from him the direction of the Naples Observatory and deprived him of the means of making researches. His age was 56 years. We have not had time to collect together an account of the checkered life and labors of these eminent men, and will return to them again in our next communication.

Weights and Measures.—A Turk, M. Bilizidkdji, has called the attention of the Academy of Sciences to the many defects in the present system of weights and measures used in Turkey, representing the necessity of establishing there a uniform system cerresponding as nearly as possible with the metric of France. The weights and measures in Turkey vary not only from Province to Province and town to town, but also according to the different professions, and the nature of products. It is nearly as it was in France before the Revolution. On the Report of General Morin, the Academy expressed the desire that the Ottoman government, as soon as the war ceased or gave leisure for it, should take up the subject and establish a plan on the metric system.

We observe in this connection that two governments have recently adopted this system, the Republic of Mexico and that of New Grenada, and orders were given to M. Silbermann to supply the standards of the system, (a metre, kilogram and liter.) These units have been finished by the late Gambey; and before delivering them over they were compared with the fundamental standards by Silbermann in the manner explained in this Journal (January and May, 1853, and page 388 of the present volume,) and verified nearly to the hundredth of a milligram or a millimetre. There are now 17 of these units at the Conservatory of Arts and Trades; they are intended for those governments that order them, or that offer their own standards of weights and measures in exchange. A score of setts have already been distributed, to the United States, Spain, different states of Germany, and Italy. England and Austria are now the only nations of the first order that do not possess them. Prussia and Russia received them long since.

Researches on Colored Impressions produced by the Chemical action of Light.—It is more than six years since M. Edmond Becquerel succeeded in preparing a surface chemically impressible to light, such that it would take the color of the luminous rays which fell upon it. He has recently returned to the subject and perfected his methods; and he now describes with details his processes which enable him to realize a species of artificial retina which is of great sensitiveness, and is acted

upon only by the visible rays of the spectrum. These rays preserve their shade of color with only a slight modification; the orange rays, for which the luminous intensity is at its maximum, are the first to impress their image, but he has not succeeded in fixing them. The sensitive material used is a chlorid of silver containing less chlorine than the ordinary chlorid, and often found mixed with the latter.

The method most successful in preparing this sensitive chlorid, consists in decomposing rapidly by an electric current a solution of chlorhydric acid in water and causing the chlorine to come in contact with the plate of silver while the latter is placed in contact with the positive pole of a battery. As it is impossible to enter into the details of these important researches, we give only these general indications of his method.

Protection against Hail.—The second volume of the works of Arago have called attention to several points in Meteorology, among which is the subject of hail and the means of protecting fields from this evil. In the chapter which he devotes to this important subject he states that in 1847, two small agricultural districts of Bourgogne had lost by hail crops to the value of a million and a half francs. Certain of the proprietors from the neighborhood went to consult Arago on the means of protecting themselves from like disasters. Resting on the hypothesis of the electric origin of the hail, he suggested the discharge of the electricity of the clouds by balloons communicating by a metallic wire with the soil, as mentioned in a preceding number of this Journal (Jan. 1853, p. 111). These projects however were not carried out; and in view of the doubts as to the electric origin of hail, he proposed to investigate the subject anew. He had not the time to bring out any results; but he persisted in believing in the effectiveness of the method proposed.

Another subject is discussed in this volume. Arago enquires whether the firing of cannon can dissipate storms. He cites several cases in its favor and others which seem to oppose it; but he concludes by recommending it to his successors. Whilst Arago was propounding these questions, a man not conversant in Science, the poet Méry, was collecting facts supporting the view; and since the publication of the second volume of Arago's work, he has been led to give his results to the public. In a remarkable pamphlet entitled "Paris futur," he concludes strongly on the efficaciousness of the firing of cannon in dissipating storms, and mentions numerous observations in support of it. He says that his attention was called to the subject in 1828, while an assistant at the "Ecole de tir" of Vincennes. Having observed that there was never any rain on the morning of the exercise of firing, he was led to examine the annals of military and revolutionary science, and he found there, as he says, facts which justified the expressions which became common, such as "Le soleil d'Austerlitz," "Le soleil de Juillet" upon the morning of the revolution of July, and he concluded by proposing to construct around Paris 12 towers of great height which he calls "tours imbrifuges," (imbrifugal towers,) each carrying 100 cannons, which should be discharged into the air on the approach of a storm. Although this pamphlet was the offspring of a man of imagination instead of a scientific man, it has attracted attention, giving occasion to some

interesting discussion of which report says the *pro* and the *con* were sustained with equal success; this was at the commencement of the present month (August); to-day the subject is forgotten; and why has it deserved to pass so soon into oblivion? It was in consequence of a negative fact. The 14th of August was a fine day. On the 15th, the *fête* of the empire, the sun shone out, the cannon thundered all day long, fire-works and illuminations were blazing from 9 o'clock in the evening. Every thing conspired to verify the hypothesis of M. Méry, and chase away storms for a long time. But towards 11 in the evening a torrent of rain burst upon Paris in spite of the pretended influence of the discharge of cannon, and gave an occasion for the mobile Gallic mind to turn its attention in other directions.

Diseases of Plants.—Communications on the cholera, the disease of the vine, of the potato, and of plants in general, have multiplied rapidly in consequence of the prizes that have been offered. Memoirs from Germany continue to come in numbers; but they have not yet presented any fact worth mentioning. A first Report on this subject was recently made by the botanist M. Montagne, who has studied the various communications with care. None are satisfactory; the theories are vague and uncertain; the methods of prevention are in general ridiculous or impracticable; and the subject is still left for the future to solve.

This is not the opinion of the "Société d'Encouragement" who have more seriously verified the facts, and according to whom, important results have already accrued to agriculture. If we cannot yet avoid the disease of the vine altogether, we know at least how to cure it; this being the result of experiments made on a very great scale at Thomery in Bourgogne where the vineyards were much infected by the disease. Injections of sulphur skilfully made, have saved the crop, and enabled the Commune of Thomery alone to send to Paris in 1853 more than a million kilograms of the white grape, ("chasselas") of excellent quality. The sulphur was applied three times in the year; it is reduced to powder, and by the aid of a bellows of peculiar contrivance it is thrown upon the vine; the application of it is made in different directions in order that the sulphur may be brought in contact with the whole surface of the plant. The first application is made when the shoots are several centimeters long, the second after flowering, the third before the grape reaches maturity. The operation succeeds best in the sun, the time taken being always from noon to 2 P. M., and 20 to 23 kilograms of sulphur are employed per hectar. In hot-houses the method is more simple, as it is sufficient to spread the sulphur on the heating tubes, when the vapor rises and answers the purpose desired.

While admitting that much remains to be accomplished, the Society has done justice to several works treating of the vine disease; that most highly honored, is the treatise of a modest agriculturalist, *M. Gontier*, who suggested the use of sulphur, an idea which he put in practice, and for which he contrived a peculiar kind of bellows. The subject is up for a prize of 20,000 francs, next year.

Dimorphism.—In the number of this Journal for May, of the present year, at page 414, I have spoken of one of my papers having for its object the determination of the influence which the medium may

exert on crystals in process of formation. I showed that by varying a saline solution by means of a substance foreign to the definite compound, we may by this means vary the molecular forces which preside in crystallization and cause a change in the crystalline type of the substance, in case the substance is susceptible of becoming dimorphous. M. Pasteur, Professor of Chemistry at the Faculty of Sciences at Strasburg, has obtained remarkable results of this nature, with dimorphous substances presenting left and right (or non-superposable) hemihedral crystals; using the two hemihedral forms of one and the same compound, as the neutral tartrate of ammonia, spoken of in preceding numbers of this Journal. These two forms belong to the system of the right rhombic prism (trimetric), and differ only in their opposite hemihedrism. But M. Pasteur has obtained with each of these two forms a second form, wholly unrelated to the first, and crystallizing in the oblique rhomboidal system [monoclinic ?], which make in all four hemihedral forms not superposable obtained with one substance.

To obtain this result, it is only necessary to take a solution of one or the other variety of this trimetric tartrate, the right or left, and add a small quantity of neutral malate of ammonia; the malate does not appear to enter into the compound; it exerts an action of presence which changes the condition of equilibrium of the molecules. M. Pasteur calls this new kind of hemihedrism, tetartohedrism; and the forms, tetartohedral.

Coloring matter of Flowers.—This question has been studied by several chemists, and still it is beyond doubt, one of the most obscure subjects in vegetable chemistry. Botanists have long admitted that flowers owe their color to two coloring principles, a blue, called *cyanic*, and the other yellow called *xanthic*. For some time the blue color of blue flowers was attributed to the presence of indigo; but M. Chevreul showed that this blue is always reddened by acids, which fact set the indigo theory aside.

MM. Frémy and Cloez have isolated the blue principle and they call it *cyanine*. To obtain it, they treat with boiling alcohol the petals of the violet or iris, until the flower is colorless and the liquid takes a fine blue tint. This tint disappears soon, but reappears on evaporating the alcohol in the air; on pouring water into the product of this evaporation, a resinous substance separates; the coloring matter remains in solution, and may be precipitated by acetate of lead; the precipitate is green; it is washed with a large amount of water and treated with sulphuretted hydrogen which removes the lead and leaves the cyanine in solution. It is gently evaporated in a water-bath, absolute alcohol is added, and then the cyanine is precipitated in bluish flocks by ether.

This coloring matter is uncrystallizable; acids turn it red, alkalies green; it combines with lime, baryta, etc; sulphurous, phosphorous and other acids discolor it; it resumes its blue color through the presence of the oxygen of the air.

The *coloring* material of roses, peonies, some dahlias, &c., is a modification of cyanine; the vegetable juices have an acid reaction (which changes the blue cyanine to red), while the juices of blue flowers are neutral. In the presence of alkalies, the rose color becomes first blue and then green.

The *yellow coloring material* has no relation to cyannine. There are two different substances, one insoluble in water, *xanthine*, the other very soluble, *xantheine* ; the former is analogous to the resins, and along with cyanine it produces in flowers an orange color, a scarlet, and a red. The xantheine combines easily with oxyds ; alkalies change it to brown of a very rich color, and of considerable strength ; but acids cause the brown color to disappear.

These are the three principal coloring ingredients of flowers. M. Filhol, Professor in the Faculty of Sciences at Toulouse, who has studied this subject, confirms in general the results of MM. Frémy and Cloez. He has however found that these coloring matters may be disguised or even destroyed by mixture with the juices of white flowers.

M. Pepin, "Chef des cultures" at the Jardin des Plantes of Paris, has made some curious observations, on the change of color which culture produces in flowers. He has found that cultivated annuals experience a change of tint more promptly than perennial plants, for each year they are renewed through the seeds. Such a change is however sometimes produced in biennials and perennials, and rarely ever in ligneous species.

The annual plants of Chili, Texas and California, have a strong tendency to produce varieties with white flowers, especially when their flowers present either of the primary colors, red, yellow or blue. The same is true of many other species introdued into France. Thus the *Clarkia pulchella* and *C. elegans* whose flowers have a violet tint, have produced white and rose-red flowers ; the *Gilia*, blue and tri-colored ; the *Leptosiphon* having red flowers, has produced pure white. The varieties with a white color are first produced, and afterwards the variegated.

Various Memoirs.—Among the more important papers read before the Academy of Sciences during the last two months, we must first notice, an important memoir by M. DAUBRÉE, Professor of Mineralogy in the Faculty of Sciences of Strasburg, on *the Artificial Production of Minerals of the family of silicates and aluminates, by the reaction of vapors on rocks.* By the reaction of chlorid of silicium in the state of vapor, and at the temperature of red heat on the bases which enter into the constitution of rocks, he obtains by double decomposition and according to the nature of the base, *crystallized quartz*, *chrysolite*, *kyanite*, *idocrase*, *garnet*, *zircon*, *etc.* A memoir of MM. MALAGUTI and DUROCHER, on *the resistance of hydraulic lime and cements to the destructive action of seawater.* A memoir of M. BECHAMP, Professor at the School of Pharmacy of Strasburg, on *the action which chlorid of iron exerts on different nitrated substances*, in continuation of a work mentioned in a former number of this Journal. *New observations on butylic alcohol*, by M. WURTZ,—the discovery of which is mentioned in the number of this Journal for Jan., 1853, p. 112. *New observations of caprilic alcohol*, by M. BONIS, a subject also alluded to in a former number. M. DEVILLE communicates *new processes for preparing Aluminium*, and he accords in these processes with those which M. Bunsen has recently described in Poggendorff's Annalen. M. MELLONI, just before his death, sent in the first part of his *Researches on Electro-static induction ;* and M. ABRIA, Professor in the Faculty of Sciences at Bor-

deaux, has presented some *Researches on the laws of the magnetism of rotation.* It is impossible to give here details of these memoirs, which moreover will all appear in the official organ of the Academy of Sciences, the Comptes Rendus, published every Saturday.

Manufacture of Powder.—In the No. of this Journal for Sept. 1853, p. 270, I have spoken of an improvement in the manufacture of powder, applied for the first time at the manufactory of Esquerdes which produces, owing to this improvement, the products highest in reputation in France or other countries. The improvement depends on a new method of preparing the charcoal, which is obtained by calcination of the wood by means of a current of overheated steam. This charcoal, called *charbon roux*, has but one objection, which is its price.

To overcome this difficulty, another member of the commission on powder and saltpetre, M. Gossart, has devised a method of executing this process, by heating with gas, which saves about 80 per cent. of the cost of the process for heating the steam.

It is apparent that this method is not only applicable to steam and to carbonisation, but may be employed with advantage whenever a fluid is to be heated. But the author has had in view specially the making of red charcoal (charbon roux), and on this point it has been examined by the committee of the Artillery. The following is an extract of the report by this committee to the Minister of War.—" With the apparatus proposed, 100 kilograms of wood may be carbonised at once. The following is the method.—The water for evaporation is injected through a pump whose piston is charged with a weight little above the force of tension desired for the vapor. The pressure causes the water to rise through a graduated orifice, in a series of tubes arranged like a ladder, and enclosed in tubes of larger bore. These last convey the gas, and also serve for the condensation of the steam after it leaves the carbonising apparatus. The circulation goes on from above downward. By this arrangement, the cold water of the tubes will absorb the greatest part of the heat of the gas and of the condensed water, thus heating itself more and more in its upward movement; it finally reaches the temperature of ebullition and is in part turned into steam in a serpentine with parallel tubes arranged so as to cover the top and sides of the furnace. The water vaporises in these tubes and is overheated in its passage across the metal turnings or granulated metal with which they are filled. The steam thus overheated is conducted into a reservoir of cast iron furnished with a thermometer and a manometer indicating its heat and tension; then it passes to the carbonising apparatus. To pass out of this apparatus, the steam and gas are conducted in the enveloping tubes mentioned above; the condensed water and the gas, now nearly cold, pass out to be rejected by an arrangement for this purpose at the lower part of the apparatus. The air for promoting the combustion is heated by passing along a portion of the walls of the chimney and the vent-holes before arriving under the grating, by which means, heat is economised. The following are the advantages of the method.

1. Only one fire is used for producing the overheated steam; and a single fireman suffices.

2. Only the amount of water actually necessary for producing the steam is heated, and just as it is required.

3. The greater part of the heat is utilised, which was before carried off by the steam and gas and totally lost.
4. The use of metallic furnaces renders it easy to multiply the heating surfaces, and at little cost.
5. The heating is regular, the temperature very equal, and the products obtained are uniform.
6. The best heating effects are secured by the arrangement for bringing the hot air under the grating."

The committee hence recommend an appropriation to enable the powder establishment of Esquerdes to make these arrangements. The appropriations have been authorized. We propose hereafter to speak of the fabrication of sugar and of distilling by this method.

Stereoscopy.—The invention of the refractive stereoscope has quite generally been attributed to Sir David Brewster, especially in France. A recent writer has corrected the error. The Abbé Moigno, in giving an account of a visit to England, in his Journal, Le Cosmos, observes that he saw in the hands of Mr. Wheatstone a letter written by Brewster, dated September 27, 1838, containing besides other things, the sentence, "I have also stated [to Lord Rosse] that you promised to order for me your stereoscope, both with reflectors and prisms." The stereoscope by refraction, says M. Moigno, as well as that by reflection, is Wheatstone's. The refracting stereoscope invented by Sir David, is a form in which the two prisms are the halves of a lens.

Photography—Painting transparent photographic images.—The coloring of photographic portraits has often been attempted; but the photograph is obliterated in the process, and after all only an ordinary painting is obtained.

M. Minotto, and also MM. Soulier and Clouzard, have succeeded in this art, by applying the color under the image. This method of coloring was used in 1824 at Strasburg, with lithographs, under the name of "oleocaleographie" and "lithrochromie." But it is especially applicable to photographs on glass, paper, tissue, and generally all transparent substances.

Photographs of monuments in Judea.—The state of art among the Jews has usually been lightly spoken of, and archeologists will not admit that they were artists. When M. de Saulcy, a French archæologist, returned from Palestine with a portfolio of crayon sketches representing the monuments of the Jews, his sketches were treated with a smile of incredulity. A photographer, M. Saltzmann of Colmar, has recently confounded the sceptic by taking the sun as his collaborator. His plates confirm the designs of M. Saulcy. They consist of 200 photographs, 50 of Jewish subjects, the rest of Roman, Byzantine, Latin, Arabic and Turkish monuments in Jerusalem.

New Collodion.—In the body of a silk worm just about to make its cocoon is found an organ full of the material which is to become silk. M. Legray has extracted from it a substance equal to albumen and collodion for photographic proofs. He proceeds thus:—He puts in a porcelain capsule the organs in question taken from 50 worms: 200 grams of distilled water are poured on it, containing 4 p. c. of carbonate of soda; the capsule is then heated, while agitating with a glass rod; after 10 to 20 minutes of ebullition, the small bags empty

themselves; they are then transferred to a piece of fine linen and pressed. The liquid is collected on glass and left to evaporate, when a pellicle forms like that of collodion. It should be used within 24 hours, as it afterwards becomes spongy and insoluble in water, alcohol and ether.

Impression by heat, or Thermotypy.—This process proposed by M. Abate is very simple, and is based on the destructive action exerted by chlorhydric acid on organic substances. Suppose for example we have a slice of wood of which we wish a faithful impression. The wood is exposed for some minutes, to the action of cold vapors of chlorhydric or sulphuric acid, or it is wet lightly with either of these acids diluted. The slice of wood, wiped with care, is placed on a piece of paper, cotton cloth, or white wood, in a press, and a blow struck. The impression is at first invisible; but on exposing it to a strong heat, it gradually appears, and exhibits a perfect picture of the wood. This operation may be repeated indefinitely. For oak, maple, hazel, &c., the picture is of the color of the wood; but for mahogany, rose wood and many others, the color is modified, and if a perfect colored picture is desired, it should be taken on a previously prepared tint of the required kind.

It occurs to us that, by taking an impression on a plate of zinc, tin, marble or other substance attacked by acids, a negative relief might be obtained, which would serve for reproducing pictures of the impressions. Finally, if the image of M. Abate is obtained with a substance which is a conductor of electricity, it may then be reproduced by electrotypy.

Electric illumination.—There have been recently some attempts made at Paris towards illuminating the bottom beneath water. At the lake d'Enghien, M. Duboscq, the successor of Soleil, performed an experiment of this kind before many competent observers. The electrodes of carbon were placed in a glass globe, being connected with one of Duboscq's regulators, which communicated with the battery by a copper wire covered with gutta percha. The globe submerged to a depth of 5 meters, spread light over a circumference of about 10 meters radius, and it remained constant for two hours, after which the carbon required replacing.

The idea of this process was suggested to Duboscq by an agent of the Company engaged in exploring the bottom of the Mediterranean where the battle of Navarino took place. The diver usually remained beneath the water three quarters of an hour, after which he came up to breathe and rest; his light was an oil lamp, placed on the head of the diver, and fed with air proceeding from his respiration, whence, it was in a variable current and was often extinguished, requiring him to go up and relight. Duboscq's arrangement was devised to avoid these inconveniences. It is light so that the diver may carry it in his hand, and at the same time it is strong and well secured hermetically, to resist a pressure of 50 to 60 meters of seawater. It consists of a cylinder of strong glass secured to a brass foot, and surrounded with a gutta percha sac. The light passes out through a large plano-convex lens, the convexity inward, the focus being so arranged that the rays escape nearly parallel. As the lamp is moveable, the diver walks about with it and places it where he wishes to make any search; and as it is only

necessary to bring the electrodes near one another to light it, the diver need only turn a small screw to continue the light for two hours, which is more than twice as long as he can remain at the bottom.

To illumine the bottom at small depths, Deleuil uses a Fresnel lens, and this is daily in operation in a bathing establishment—the baths of Henry IV, constructed on the Seine in the heart of Paris. The regulator and also the light are 10 meters above the surface of the water, and the light penetrates sufficiently far to enable us to see the swimmer at a depth of 2 to 3 meters, and follow all his movements.

2. *Notice of the "Fountain of Blood" in Honduras.*—The following letter from E. G. Squier addressed to B. Silliman, Jr., refers to a remarkable phenomenon in Central America, the details of which are sufficiently given in the letter of Mr. Squier. The bottle of colored liquid which was placed by this gentleman in our hands has suffered the same fate as its predecessors, and its contents were so far changed by decomposition as to preclude all attempts at an accurate examination. The color of the fluid was dark brown, exhaling an offensive odor, and having a sediment somewhat copious in which the microscope detected no distinct forms of organization, although filaments of organic matter were abundant. The most probable conjecture as to the origin of this fluid, appears to be that which refers its color to the presence of some highly colored species of infusoria. A microscopic examination on the spot or a portion of the material in alcohol would easily settle the question. Meanwhile the following facts will be read with interest.

"*My Dear Sir*:—I send you herewith a bottle of a remarkable liquid obtained from what is called "*Mina ó Fuente de Sangre*," Mine or Fountain of Blood, in Central America. The locality is a small cavern, near the little town of Virtud, Department of Gracias, State of Honduras, on the western or Pacific slope of the Cordilleras. It has long been known, not only in its immediate vicinity, but in connection with various superstitious hypotheses, throughout all Central America. Mention is made of it in publications, dating back more than a hundred years. The following extracts from the '*Gaceta de Honduras*,' of the 20th of February, 1853 will serve to give the essential facts concerning it, so far as they are known:

'*Fuente de Sangre.*—A little to the south of the town of Virtud, Department of Gracias, is a small cavern (*gruta*) which is visited during the day by buzzards and *gabilanes*, and at night by a vast number of large bats (*vampires*), for the purpose of feeding on a kind of liquid which exudes from the rocks, and which has the color, smell, and taste of blood. A rivulet flows near this grot, which is constantly reddened by a small flow of the liquid. A person approaching the grot observes a disagreeable odor, and when it is reached, he sees several pools of the blood, in a state of coagulation. Dogs eat it eagerly. The late Don Rafael Osejo undertook to send some bottles of this liquid to London for analysis, but it corrupted within twenty-four hours, bursting the bottles.'

At my request Don Victoriano Castillanos, a gentleman of an observing turn living not many leagues from Virtud, sent me two bottles of this liquid, largely diluted with water, to avoid the catastrophe which happened to Gr. Osejo, and to all others who had attempted to carry

any portion of the supposed blood out of the country. One of these bottles, as I have already said, I send to you for examination, believing that the results may not be uninteresting to the readers of the Journal.
New York, May 1, 1854."

3. *Nature doing her own engraving.*—In the fifth volume of the Denkschriften of the Royal Academy of Sciences at Vienna (Mathematico-Natural History Class), there is a paper by Alois Auer, and numerous plates, illustrating a new style of engraving. The plates represent leaves, plants from a herbarium, lace and other objects, and in each case, the object appears to be *on the paper*, the surface being raised and the coloring perfect. The deception is so complete that without a magnifying glass it is almost impossible in one or two instances to be sure that the object itself is not there. The process employed is the following: The pressed plant, or other object, is placed between a plate of copper and one of lead and subjected to pressure; the original thus produces a strong impression on the lead plate. By inserting the requisite colors with a point, in the depressions, a figure colored to nature, with different colors in its different parts, may be obtained at a single printing. From the lead plate copies may be taken by stereotype or galvanism, and copper plates are thus obtained more durable than those of lead. Gutta percha may be used in place of the lead, and by covering it with a deposit from a silver solution, the impression may be used for stereotyping or electrotyping.

4. *Mount Ararat and places in the Caspian Basin.*—Mount Ararat was ascended by Col. Chodzko of Russia in 1850. He found the height to be 15,912 French feet; and for Little Ararat 3852 feet less in elevation. M. Fedoroff found in 1829, 16,069 for the former and 12,232 for the latter. Parrot obtained 16,251 and 12,271 feet.

Lake Goktchaï near Erivan is not less than 5,510 feet (French) above the sea; and on its borders to the south and southeast there are ancient volcanoes 8000, 10,000 and 11,000 feet in height.

The height of the city of Teheran above the sea is 3579 French feet; of Meched 2865; that of the high mountain Schemrunn 12,247 feet; the famous peak of Demavend 18,846 feet, (which Frazer had made 10,000 feet, T. Thomson 14,000, Texier 4548 meters, and Humboldt in his *Central Asia*, vol. iii, 3066 toises.

The *lake Aral* derived its name from the string of islands on the east and north sides, the word in the Kirghis dialect meaning island. The lake is 50 leagues (French) broad and 100 long and about 109 times the surface of the lake of Geneva. The waters have the saltness of Finland, 25 leagues west of Cronstadt. The greatest depth, about 37 toises, is on the west side. It does not contain seals or crabs like the Caspian, nor various large species of fish which occur in that sea.—*Bib. Univ. de Genève, June*, 1854.

5. *Zodiacal Light.*—By letters from Rev. George Jones, U.S.N., now of the Japan Expedition, we learn that he has made numerous observations on the zodiacal light, leading to important conclusions. He remarks that "the light never fails to be seen when the moon or clouds do not interfere," a statement which accords with the observations of the writer. His results will be published on the return of the Expedition.—J. D. D.

6. *Notes on California;* by W. P. BLAKE, (from a letter to one of the Editors.)—I found a greater number of intruded igneous rocks in the Gold region than I anticipated. They vary in character and are probably of different ages. The prevailing trend is N. to N. 45° W., and when traversing slates they are generally comformable to the bedding. Quartz veins bearing gold are usually found connected with these intrusions and either traverse their mass or constitute a wall between them and the adjoining slates. Quartz veins traversing the slates *conformably* and *obliquely* without any apparent connection with the igneous intrusions are also common.

Some of the auriferous quartz veins are worked with great profit. Of this, I am satisfied from careful examination, and I have many interesting details on this subject.

The elevated placer deposits are very extensive, and are worked with much skill and success.

The numerous exploring shafts sunk in all parts of the country on the tops of the hills, have developed many interesting facts concerning auriferous drift. There is in most places where placer mining is being conducted above the present rivers, a thickness of two hundred feet or more of stratified materials that appear to have been laid in comparatively quiet water. The peculiarities of these deposits are so various and they are so different from those generally known as drift, that a wide field is opened for investigation and many detailed observations will be required, before we can understand the changes that have taken place in this part of the continent during and since the "drift period."

Since I wrote you about the gold and platinum from Port Orford, I have examined several other samples and find that the percentage of platinum is variable, and that iridosmine is generally in large proportion. I have now several ounces of the mixed metals separated from the gold. The grains are very hard but are probably too small to be used in the manufacture of pens.

7. *Homœography.*—A new method of copying pages of a printed work by transfer, invented by M. Edward Boyer in France, is thus named. It is claimed that any book or engraving may be thus copied with little expense, and copies multiplied indefinitely, so that a book, however rare, never need be out of print. It is done rapidly, without injuring the original, and so exactly that the most practised eye cannot tell the difference.

8. *Sketch of the Life and Labors of Dr. Thomas Thomson*, F.R.S., &c., Prof. Chem. Univ. Glasgow, etc., delivered at the opening meeting of the Glasgow Philosophical Society of Nov. 5, 1852, by WALTER CRUM, F.R.S., Vice-President of the Society.—Dr. Thomson died on the 2d of July, 1852, at 80 years of age, after long service in the cause of science. Mr. Crum gives the following facts showing the part Dr. Thomson took in the promulgation of the Atomic Theory.

"On the 26th of August, 1804, Dr. Thomson went to Manchester, and saw for a day or two much of Mr. Dalton, who explained to him his views on the composition of bodies. He saw at a glance, as he tells us, the immense importance of such a theory, and was delighted with the new light which immediately struck his mind. He wrote down at the time the opinions which were offered, and three years later, when

about to publish the third edition of his System of Chemistry, he obtained Dalton's permission to insert the sketch he had taken, before Dalton himself had given it to the world. The theory was at that time very slenderly supported by facts, for chemists possessed few experiments which could be considered as even approaching to accuracy. Up to this time when Thomson published the sketch, he seems to have been Dalton's only convert. Perhaps no other chemist had taken the trouble to listen to it, if we except Dr. Henry of Manchester, who was Dalton's frequent visitor, but there is no probability that even he at so early a period accepted the theory, for he speaks of it, so late as 1810, in rather doubtful terms, in the sixth edition of his "Elements."

Thomson's paper on the oxalates, read to the Royal Society in 1807, contained the first direct example of the application of the Daltonian theory to supersalts. He there shows that oxalic acid unites with strontian as well as with potash in two different proportions, and that the quantity of acid combined with each of these bases in their superoxalates, is just double of that which saturates the same quantity of base in their neutral compounds. During the same year Dr. Wollaston read his famous paper on the oxalate, binoxalate, and quadroxalate of potash, and he commences it with a relation of what Thomson had already done. He states that he had remarked the same law to prevail in various other instances of superacid and subacid salts, and that he had intended to pursue the subject so as to learn the cause of so regular a relation; but that such a pursuit was rendered superfluous by the appearance of Dalton's theory, as explained and illustrated by Thomson. He shows also that the bicarbonate of soda loses one-half its carbonic acid by exposure to a red heat—that the potash in supersulphate of potash is united to twice as much acid as the same quantity of potash in the neutral sulphate, and that potash unites with three different quantities of oxalic acid, which bear to each other the relation of 1, 2, and 4. Dr. Thomson always said, that in the absence of Dalton, Wollaston would have been, very soon, the discoverer of the atomic theory.

These facts gradually drew the attention of chemists to Mr. Dalton's views. Sir Humphry Davy, however, and others of our most eminent chemists, were hostile to them. In the autumn of 1807, Dr. Thomson had a long conversation with Mr. Davy at the Royal Institution, during which he attempted in vain to convince him that there was any truth in the new hypothesis. A few days after, he dined with him at the Royal Society Club at the Crown and Anchor in the Strand. Dr. Wollaston was also present. After dinner every member left the tavern, except Dr. Wollaston, Mr. Davy, and himself, who all remained behind, and sat an hour and a-half conversing upon the atomic theory. Wollaston and Thomson tried to convince Davy of the inaccuracy of his opinions; but he went away more prejudiced than ever. Soon after, Davy met Mr. Davies Gilbert, the President of the Royal Society, and exhibited to him the atomic theory in so ridiculous a light, as to make Mr. Gilbert call afterwards on Dr. Wollaston, to learn, probably, what could have induced a man of his sagacity and caution to adopt such opinions. Dr. Wollaston begged of Mr. Gilbert to sit down and listen to a few facts which he would state to him. He then went over the principal facts, at the time known, respecting the salts in which the proportion of one

of the constituents increases in a regular ratio; and the relations also which Dalton had found carbon to bear to hydrogen in olefiant gas and carburetted hydrogen. Mr. Gilbert went away a convert to the truth of the atomic theory, and had soon the merit of convincing Sir Humphry Davy, who ever after was a strenuous supporter of it.

Instead of Dalton's term "atom," which Thomson adopted, Davy always used the word "proportion," and Wollaston "equivalent," which was much better; but whatever term we employ, now that the thing itself is understood, there can be no doubt that the use of the word "atom," (which conveys at once the idea of an ultimate indivisible particle,) greatly contributed to the reception of the doctrine of definite proportions. In 1808 Mr. Dalton published a volume of his own, in which not more than five pages, widely printed, and one plate with explanations, were devoted to the announcement and illustration of the atomic theory. This treatise, if such it can be called, is little more copious than that which had been given the year before from Dr. Thomson's notes."

9. *Prefatory Notice of Laurent's Méthode de Chemie;* by J. B. Biot.—This work, rich in new ideas, which have often proved fruitful to the author himself, offers us the deep convictions of a man who has enriched science with numerous and unexpected discoveries. It is the review of the thoughts of his life; and he felt so deep an interest in leaving behind him this bequest, that he labored to complete it even while in the arms of death. These reasons demand that the work should be received with serious consideration, and a mind free from previous prejudices. But to read it with profit and a just appreciation, it is important to bear in mind the *end* which Laurent had in view in its composition. He desired to place in the hands of chemists a collection of analogies drawn from experiment, which should guide them by the strongest probability if not with entire certainty, in the explanations to which they are continually obliged to have recourse. The operations of chemical analysis, whether applied to native or to artificial products, make known only the nature and relative proportions of the elements which compose them. They cannot teach us whether the molecules of the constituent elements are combined in all cases according to a single general mode alike for all; or whether they are distributed into distinct groups, combined among themselves without individual decomposition, and coexisting with their peculiar properties in the complete product. This question it is all important to decide, and to ascertain the special conditions in either case. For we should expect that the reactions of a substance would differ according as its molecular constitution is homogeneous or heterogeneous; and in the latter case according to the nature of the groups therein associated. Thus there are abundant examples of bodies, formed from the same simple elements and in the same proportions of weight, which are wholly diverse in chemical and physical properties. On this point, the most elevated in chemical reasoning, analysis gives no direct information, since its results only distinguish the simple elements separated from each compound, and affirm nothing as to whether they are isolated, or combined in groups whose preëxistence cannot be affirmed. Hence it may be justly said that it judges of bodies only after they have ceased to exist.

The preëxisting state of such bodies can therefore be determined only by induction, and must rest upon the analogies of properties and reactions; or else upon theoretical views which by giving a simple conception for each body under consideration connects it by probable marks with those substances with which it appears to have the closest relations in molecular constitution.

Now this latitude which each chemist allows to himself in each particular series of his investigations, has introduced great confusion into the science which must still increase; particularly in proportion as we advance in the study of organic products, where the combinations of a small number of simple substances, always the same, present a diversity almost infinite. Laurent has had in view to control the exercise of this liberty by subjecting it to general and uniform laws. Among the great number of formulas by which the bodies made known by chemical analysis can be theoretically represented, he proposed to seek out those which in the present state of our knowledge should be preferred, as offering the most general advantages for classification and the practical study of compounds; and by bringing together analogous species and separating those which are unlike by characters both numerous and striking, to enable one to foresee, from a careful inspection of the symbolic formulæ, the greatest possible number of reactions which they may exert and the products which may be thereby deduced from them. In a word, he has attempted by a comprehensive method, to do that for the collected researches of the chemical science of the day, which each chemist is trying to do in his own line of research, with limited and arbitrary views. Has he succeeded in this great task, for which perhaps chemical science hardly offers sufficient material in the way of well ascertained facts? This no one will be bold enough to affirm, nor unjust enough to demand. The inquiry we should make in reading his work is, whether, in the majority of cases on which he has relied to sustain himself, his views are conformable to experience; so that each may have a chance of finding them fruitful in his own case, as they have been to Laurent and others. If they have this effect, even within these limits, he will not fail to applaud, while laboring to carry the principles to perfection. To repel or reject them at first view because they are strange or perhaps announced with too great boldness of expression, would be a policy little likely to advance science. If our author sometimes attacks rather rudely the edifice of chemical science which has been formed by slow and successive additions, it is because, seeing the incoherence of the accumulated materials composing it, he has believed it to be more profitable to labor for its reconstruction, than strive to preserve it as it is. He has aimed only to assist in the undertaking, by pointing out the relations of types and symbols, which, in the absence of more accurate notions, offer generally some reliable grounds for grouping or separating species. In a majority of cases, chemistry will thus be able to escape from that empiricism in which until lately it has remained.

The power of rotating polarized light exercised by a great number of bodies, as far as known exclusively organic, furnishes a definite character by which the abstract speculations based upon the constitution of the compounds of which they form a part may be either confirmed

or set aside. The application of this character, thus directed, offers a direct and sure method, for resolving a multitude of controverted questions in rational chemistry, of the kind which Laurent has treated. But the employment of this method is as yet but little extended, although it has always been fruitful for those who have employed it in their researches.

10. *Smithsonian Contributions to Knowledge.* Vol. VI. 1854.—In the volumes of able papers which are issued under the Smithsonian fund, this Institution is conferring a lasting benefit on the cause of knowledge through the land and through the civilized world. Works, the result of profound research, which would fail of a publisher because not fitted to command a ready "cash" return, here find encouragement and the means of an honorable introduction to the libraries of the land, and directly or indirectly, the views, new principles, and results of researches and explorations over this and other lands, gradually pass into general circulation. The volume just now issued, the sixth of the series, contains the following memoirs:—

Plantæ Fremontianæ, or Descriptions of Plants, collected by Col. J. C. Fremont in California; by John Torrey. 24 pp. and ten plates.

Observations on the Batis maritima of Linnæus, by John Torrey. 8 pp. and one plate.

On the Darlingtonia Californica, a new Pitcher Plant, from Northern California; by John Torrey. 8 pp. and one plate.

Synopsis of the Marine Invertebrata of Grand Manan, or the Region around the Bay of Fundy, New Brunswick; by Wm. Stimpson. 68 pp. and three plates.

On the Winds of the Northern Hemisphere; by James H. Coffin, Prof. of Mathematics and Natural Philosophy in Lafayette College, Pa. 200 pp. and 13 plates.

The Ancient Fauna of Nebraska, or a Description of Remains of Extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska; by Joseph Leidy, M.D., Prof. Anat. Univ. of Pennsylvania. 124 pp. and 25 plates.

Appendix: Occultations of Planets and Stars by the Moon, during the year 1853, computed by John Downes.

The long paper by Prof. Coffin consists largely of tables, presenting abstracts of observations, bearing on the winds and temperature of the different zones and regions of the globe. It embodies also deductions from the observations, which are of great interest, although of course liable to modifications in some cases, as facts are further multiplied. The following are some of these conclusions:

(1.) In the Arctic regions of North America, within the Polar circle, the mean direction of the wind is about *north-northwest*, and well defined.

(2.) Between the parallels of latitude—60° and 66° there appears to be a belt of easterly or northeasterly winds.

(3.) South of this belt, there is a zone of westerly winds, (as now commonly recognised) which encircles the globe, and is about 23½° in breadth. Near the limits which divide this zone from the Polar winds on the north and from the equatorial on the south (particularly the latter)

the progressive motion is very small. The progressive motion moreover is less in Europe than in America.

(4.) South of this zone and contiguous to it, the winds in the United States and on the Atlantic are on the whole easterly, though quite irregular, with small progressive motion.

(5.) Further south, there are the well known northeasterly trade winds, stronger between 10° and 25° than nearer the equator. In the eastern Atlantic near Africa, the winds incline towards the great Desert. In southwestern Asia, they are very irregular, and defy all attempts to reduce them to system.

The system of winds of the northern hemisphere are therefore regarded by the author, as (1) a southerly in direction in the high northern latitudes, but veering towards the west as they approach a limit ranging from about latitude 56° on the western continent to about latitude 68° on the eastern, when they become irregular and disappear; the area of this zone is about 11,800,000 miles; (2) a zone of westerly winds around the earth less than 2000 miles broad; area about 25,870,000 square miles; (3) south of this last zone, a zone of easterly winds—area about 60,760,000 square miles.

(6.) On each side of the Atlantic there is a system of winds possessing monsoon features. Drawing curved lines to represent the mean annual and the monthly tracks, the curves for the warmer months, fall inside of the mean in the warmer months and outside in the winter, showing a deflection towards the land in the former and towards the sea in the latter—an effect which the author alleges to be "most convincing proof of the influence of heat in the production of winds and that too upon an extensive scale." These monsoon winds are stated to be analogous to land and sea breezes, only on a grander scale. The influence of the northern lakes on the direction of the wind, and also of deserts, is discussed in this connection.

These are some of the points brought out in Professor Coffin's paper.

The extended paper on the Nebraska fossil Mammalia by Prof. Leidy, contains elaborate descriptions and illustrations of the ancient Fauna of the remarkable Mauvaises Terres, an earlier less complete paper on which by the same author has already been noticed in a former number of this Journal. The Mammalia all belong to the order Ungulata or hoofed Mammalia, excepting a single carnivorous animal of the feline genus Machairodus. Of Chelonian Fossils, there are five species all of the genus Testudo. The following are the names of the Ungulata described.

Poebrotherium Wilsonii, Leidy—most nearly allied to the musks.

Agriochœrus antiquus, Leidy.—In structure between the ordinary Ruminants and the anomalous Anoplotherium.

Oreodon, Leidy.—Also between ordinary Ruminants and the Anoplotherium. Species Oreodon Culbertsonii, about the size of the wolf of Pennsylvania; *O. major*, larger than the Culbertsonii.

Eucrotaphus, Leidy.—Probably related most nearly to Oreodon. Species, *E. Jacksoni* and *E. auritus*.

Archæotherium, Leidy.—A genus of Suilline Ungulates.

Species, *A. Mortoni.*—Head about as large as that of the Lion. *A. robustum*, still larger.

Anchitherium, Meyer.—Related to Palæotherium.

Species *Anchitherium Bairdii.*

Titanotherium, Leidy.—Related to Palæotherium. Species *T. Proutii*, (this Journal, 1847, iii, 248.)

Palæotherium giganteum, Leidy.—Twice the size of the P. magnum.

Rhinoceros occidentalis, Leidy.—Three-fourths as large as the R. indicus. *R. Nebrascencis*, one-fourth smaller than the R. occidentalis.

The species of Carnivora described is the *Machairodus primævus*, an animal a little smaller than the American Panther.

The plates illustrating this paper are admirable. The Mauvaises Terres or Bad Lands, are situated near latitude 42° N. and longitude 26° west from Washington, or 103° west from Greenwich.

11. *Verd Antique Marble.*—The papers state that the new City Hall of New York is to be built of Verd Antique or Serpentine marble, either from Vermont or the quarries of Milford, Connecticut. The latter is a miserable material for all out-door use, though elegant for in-door purposes. When the Milford quarries were first opened some 35 to 40 years since, the polished slabs were used as monuments in the New Haven Cemetery; and now they are as gray and rough as if remnants of Assyrian antiquity. The Vermont material is more purely a serpentine rock, and will not wear as unevenly. But unpolished, it is a dull, blackish, gloomy stone, turning brownish gray on exposure, and fit only for a prison. It is quite time that in the selection of building material for public structures in the United States, some reference should be had to the quality and fitness of the rock. The Greeks were wise in using material which 2000 years have not wasted nor diminished in beauty.

12. *Mastodon.*—A skeleton of a Mastodon has been recently discovered buried in a marsh about two miles from Poughkeepsie, New-York. Its state of perfection is not known, as it is yet but partly exhumed. This is the second skeleton obtained from the vicinity of this city.

13. *British Association.*—The British Association commenced its session for the present year at Liverpool, on the 20th of September last.

14. *Ueber das Iridium und seine Verbindungen.* Inaugural-Dissertation zur Erlangung der Philosophischen Doctorwürde von Ezequiel Uricoechea, aus Bogota. 38 pp. 8vo. Göttingen, 1854.—The author of this Inaugural Dissertation, Mr. Uricoechea, from Bogota, has just graduated with honors at the Göttingen University, in the Department of Philosophy. A history of the discovery of the Platinum metals is first given, in the course of which he observes that, the word Platina, although derived from the Spanish *Plata*, silver, is not properly a diminutive of that word, but signifies more correctly *silver-like*, or like silver. He cites the sentence from Scaliger, of the 16th century, in which he alludes to this metal, as follows: "Præterea scito, in funduribus qui tractatus est inter Mexicum et Dariem, fodinas esse orichalci quod nullo igni, nullis Hispanibus artibus, hactenus liquescere potuit;" and also, the subsequent notice of it in the Relacion historica, &c. of Ulloa, "Donde la Platina (piedra de tanta resistencia que no es fácil

romperla ni desmenuzarla con la fuerza del golpe sobre el Yunque de acero) es causa de que se abandonen; porque ni la calcinacion la vence; ni el arbitrio para extraer el metal que encierra, sino á expensas de mucho trabajo i costo." The author ably reviews also the scientific history of the platinum metals, and especially of Iridium, and closes with some results of his own investigations on the Phosphate of oxyd of Iridium, Bromid of Iridium and Sodium, Bromid of Iridium, Sulphates of oxyd of Iridium and Chlorid of Iridium and Magnesium.

15. *The Chemistry of Common Life;* by JAMES F. A. JOHNSTON, M.A., F.R.S., F.G.S., &c. 12mo. New York, 1854. D. Appleton & Co. Nos. I, II, and III.—The subjects treated of in these three Nos. are "The Air we Breathe," "The Water we Drink," "The Soil we Cultivate," "The Plants we Rear," "The Bread we Eat," "The Beef we Cook," "The Beverages we Infuse," "The Sweets we Extract," "The Liquors we Ferment," and first part of "The Narcotics we Indulge in." In all 270 pages 12mo.—Science is here brought to bear successfully and attractively on the common processes of domestic and outdoor life. The three numbers issued are about half the whole work.

16. *Scenery, Science and Art, being Extracts from the Notebook of a Geologist and Mining Engineer;* by Professor D. T. ANSTED, M.A., F.R.S., &c. 324 pp. 8vo. London, 1854. J. Van. Voorst.—Prof. Ansted's work contains brief but animated descriptions of the people and country met with in his travels, ranging through portions of France, Switzerland, Germany, Spain, Sardinia, Algiers, and the United States; and many excellent views, part in lithotints, illustrate the scenes of which it treats. A large part of the volume is devoted to the mines, mining resources and geology of the regions visited, and these add largely to the substantial value of the work.

17. *Souvenirs d'un Naturaliste;* par A. DE QUATREFAGES, Membre de l'Institut. In 2 vols. 18mo. Paris, 1854. Victor Masson.—The author of this work, A. De Quatrefages, is one of the most active and thorough Zoologists of France. These volumes are in part a popular Journal of his various excursions to the Mediterranean and other regions, and partly reflections and discussions on scientific topics, of more or less general interest. His object, as he states, in his Preface, was to present the great truths and principles of zoology in a manner that should make their true bearing, interest and value apparent to the public at large. Whether speaking of the incidents of his tours, the people among whom he is cast, or of science, the work is interesting and instructive.

18. *The Principal Forms of the Skeleton, and of the Teeth;* by Professor R. OWEN, F.R.S., &c. 330 pp. 12mo. Philadelphia, 1854. Blanchard & Lea. This book is by the most eminent Comparative Anatomist of Britain. It was written as an introduction to his favorite Science, and reviews the structure of the principal forms of the Skeleton, and of the Teeth in the Vertebrata. It is illustrated by many wood-cuts.

19. *Principles of Comparative Physiology;* by WM. B. CARPENTER, M.D., F.R.S., &c. 752 pp. 8vo, with 390 wood-cuts. A new American, from the 4th and revised London edition. Philadelphia, 1854. Blanchard & Lea. The whole range of organic nature, both vegetable

and animal, is treated of in a physiological point of view, in this elaborate work of Dr. Carpenter: and there is no Treatise in the English language, that covers the same ground in so able a manner.

20. *Human Physiology*, designed for Colleges and the higher Classes in Schools, and for general reading; by WORTHINGTON HOOKER, M.D. 390 pp. 12mo, with nearly 200 wood-cuts. New York, 1854. Farmer, Brace & Co.—Dr. Hooker writes with perspicuity, explains difficult points with simplicity, and adapts his subject well to school instruction and general reading. His work treats first, of the general distinctions of organized and unorganized substances, the distinctions of animals and plants, and man's relations to the three kingdoms of nature; second, of the Human Structure as bearing on Physiology; and third, the uses for which the structure is designed.

21. *Science and Mechanism Illustrated by Examples in the New-York Exhibition*, 1853–54; including extended descriptions of the most important contributions in the various departments, with annotations and notes relative to the Progress and present state of applied Science and the useful Arts. Edited by E. R. GOODRICH, Esq., aided by Professors HALL and SILLIMAN, and other scientific and practical men. New York, G. P. Putnam & Co. 1854. 4to, pp. 258, with numerous illustrations.

This long expected volume has at last appeared and is published in a uniform style with the Illustrated Record, of last year. It embraces a vast variety of information, much of it novel and curious, upon the wide range of topics covered by its 31 Classes. The parts devoted to Mineralogy, Geology and Mining (Class I.) to Chemical and Pharmaceutical products (Class II.) and to Philosophical Instruments (Class X.) are those most interesting to men of science. As space does not permit at this moment any extended abstracts of its contents, we shall take occasion to refer to it again at an early day.

22. *History of the Fishes of Massachusetts;* by DAVID HUMPHREYS STORER.—We have just received a second part of this valuable work, extending from page 91 to 130. It embraces descriptions of species of the Genera Blennius, Gunnellus, Zoarces, Anarrhicas, Lophius, Chironectes, Batrachus, Ctenolabrus, Tautoga, Pimelodus, Cyprinus, Leucosomus, Hypsolepis, Cheilonemus, Argyreus, Catostomus, and Fundulus; and is illustrated with plates 17 to 23, containing figures of the species.

23. *The Principles of Animal and Vegetable Physiology;* a popular Treatise on the Functions and Phenomena of organic life, to which is prefixed a general view of the Great Departments of Human Knowledge; by J. STEVENSON BUSHNAN, M.D., Physician to the Metropolitan Free Hospital, &c. 234 pp. 12mo., with 102 wood-cuts. Philadelphia, 1854. Blanchard & Lea.—There is little of almost everything in this small duodecimo volume.

24. *System der thierischen Morphologie*, von Dr. J. VICTOR CARUS, Prof. der vergleichenden Anatomie in Leipzig. 506 pp. 8vo, with 97 wood-cuts. Leipzig, 1853. Wm. Engelmann.—Dr. Carus, the learned Comparative Anatomist of Leipzig, discusses in a manner both philosophical and profound, the general principles of form and structure in the animal kingdom. The structures of the different simple and complex organs are described with comprehensive views of their relations; next

the processes of growth or developement, and then the particular structures presented by the different types of animal forms. The work closes with chapters on the fundamental relations of type series, and the essential idea of the animal structure.

25. *Atlas von Nord America, nach den neuesten Materialen*, in 18 Blättern mit erläuterndem Texte, herausgegeben von HENRY LANGE. Braunschweig, 1854. G. Westermann.—This Atlas of North America contains 18 plates.—The first is a general map of North America; the next twelve are devoted to the several states of the United States; the 14th to British America; the 15th is an ethnographical chart; the 16th illustrates the distribution of mammalia over North America; the 17th the distribution of plants; the 18th is an enlarged map of San Francisco, the Sacramento and San Joaquin. The maps, although small, are admirably executed, and are remarkable for the fidelity with which they give recent results. The form of the Atlas is a broad quarto, and with each plate there is a leaf of text containing statistical details.

26. *Of the Plurality of Worlds, an Essay.* 279 pp. 18mo. London, J. Parker & Son.—The author of this able essay, whose name does not appear on the title page, endeavors to prove that our own world is the only one in space which is inhabited by rational beings. The argument is conducted with consummate skill and great power, usually with fairness, although sometimes sophistical when direct reasoning was insufficient, and in all parts with ennobling thoughts of man's relations and destiny. With regard to the planets of our system, the evidence is very nearly conclusive that the earth is nearly or quite alone in being tenanted by man. Jupiter, as its density is but 1·1, or little above that of water, is regarded as mostly liquid; Saturn, which is not heavier than cork, as made up mainly of liquid and vapor; and thus all the outer planets are stated to be unfitted from their nature as well as the absence of light and heat, for the higher orders of life. The Earth, the largest of the *solid* planets, is in the temperate zone of the Planetary system, and air, earth and water have here their most equable relations. The argument respecting the fixed stars carries far less, we should say, very little, probability with it. The work has been republished in this country.

27. *More Worlds than one;* by Sir DAVID BREWSTER, is the title of a work written in reply to "The Plurality of Worlds."—The distinguished author rests much on the ground that the making of a world is waste labor unless the surface is afterward stocked with inhabitants; and without a very strict appeal to the analogies furnished by science, he counts much on what Infinite power *may* do in adapting rational creatures to conditions of all possible kinds. The sun, the lava-covered moon, and even Neptune which rolls through space in a perpetual Arctic night, are supposed to have their inhabitants. In these deductions, the work goes to an extreme the opposite of that of "The Plurality of Worlds."

28. *Sixty-seventh Annual Report of the Regents of the University of the State af New York.* 316 pp. 8vo. Albany, 1854.—This Report, like its predecessors, contains much information in the department of Meteorology, besides the various School Reports.

29. *Seventh Annual Report of the Regents of the University of the State of New York, on the Condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto.* 124 pp. 8vo. Albany, 1854.—In addition to lists of recent additions to the State Collections, this volume contains analyses of specimens of salt from different salt mines, domestic and foreign, and a memoir with two plates, on the Serpents of New York, by SPENCER F. BAIRD.

30. *Popular Lectures on Drawing and Design;* by WM. MINNIFIE, Professor of Drawing in the School of Design of the Maryland Institute. 53 pp. 12mo. Baltimore, 1854.—This small pamphlet is made up mostly of popular addresses on some public occasions by the author.

ERASMUS WILSON, F.R.S., Healthy Skin: A Popular Treatise on the Skin and Hair, their preservation and management. 2d American, from the fourth and revised London edition, with illustrations. 292 pp. *Philadelphia*, 1854. Blanchard & Lea. 75 cents.

MÉMOIRES de l'Académie Royale des Sciences de Belgique, Tome 27, 1853; Mémoires couronnés et Mémoires des Savants étrangers, Tome 25, 1851-1853. This last volume contains a memoir of 326 pages and 38 fine plates, on the Fossils of the Secondary Formations of Luxembourg, by M. F. Chaupuis and M. G. Delwaque.

JOURNAL OF THE UNITED STATES AGRICULTURAL SOCIETY. 279 pp. 4to. *Boston*, 1854. Published quarterly.

REPORT OF THE TWENTY-THIRD MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, held at Hull in September, 1853. 212 and 142 pages, 8vo. 1854.

DR. HERMANN SCHILDENER: Der Process der Weltgeschichte als Grundlage der Metaphysik oder Wissen des Wissens ist Wissen der Geschichte. 228 pp. 8vo. Greifswald, 1854. G. A. Koch'sche Verlags-Buchhandlung, Th. Kunike.

PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA. Vol. VII, No. IV.—p. 122. Description of new species of Viviparous marine and freshwater fishes from California; *W. P. Gbibons.*—p. 128. Note on Entophyta; *J. Leidy.*—p. 129. Descriptions of New Fishes collected by Dr. A. L. Heermann, Naturalist attached to the Survey of the Pacific Railroad route, under Lieut. R. S. Williamson, U. S. A.; also (p. 141) of Marine Fishes from San Francisco, collected by Dr. Kennerly, attached to the Survey under Lieut. A. W. Whipple; also (p 142) of Fishes from the Pacific coast collected by Lieut. W. P. Trowbridge, U.S.A.; *C. Girard.*—p. 156. Synopsis of Extinct Mammalia, the remains of which have been discovered in the Eocene formations of Nebraska; *Dr. Leidy.*—p. 158. Notice of a new genus of Cyprinidæ; *S. F. Baird* and *C. Girard*—Synopsis of the Erotylidæ of the United States; *J. L. LeConte.*—p. 163. Descriptions of new fossil species from the Cretaceous formation of Sage Creek, Nebraska, collected by the North Pacific Railroad Expedition, under Gov. J. J. Stevens; also from the freshwater formation of Nebraska; *J. Evans* and *B. F. Shumard.*

COMPLETE WORKS OF M. ARAGO. *Paris*, chez Hector Bossange.—Two volumes have appeared; the first containing historic eulogies (of Young, Fresnel, Watt, Volta, Fourier, Carnot), and also the history "de ma jeunesse;" the 2d containing Notes on Thunder, the Aurora borealis, Electro-magnetism, Magnetism of rotation discovered by Arago, and some words on Table Turnings.

The following works also are published by H. Bossange:

DE LA BAGUETTE DIVINATOIRE, DU PENDULE DIT EXPLORATEUR, ET DES TABLES TOURNANTES, au point de vue de l'Histoire, de la Critique et de la Méthode expérimentale; par M. Chevreul, Membre de l'Institut. Volume in-8, 1854. Prix: 5 francs.

BOILEAU, Professeur de Mécanique appliquée à l'Ecole d'application de l'Artillerie et du Génie.—Traité de la mesure des eaux courantes, ou Expériences, Observations et Méthodes concernant les lois des vitesses, le jaugeage et l'évaluation de la force mécanique des cours d'eau de toute grandeur; le débit des pertuis des usines, des fortifications et des canaux d'irrigation; et l'action dynamique des courants sur les corps en repos. In-4, avec 7 pl.; 1854. 20 *fr.*

YVON VILLARCEAU, astronome à l'Observatoire de Paris.—Sur l'Établissement des Arches de Pont, envisagé au point dé vue de la plus grande stabilité, et Tables pour faciliter les applications numériques. In-4 avec figures dans le texte et 2 planches; 1854. 12 *fr.*

INDEX TO VOLUME XVIII.

Erratum.—Vol. xvii, p. 431, 16th line, after ilmenite, add "to calcite and other hexagonal species."